SCIENTIFIC AMERICAN SUPPLEMENT. № 1672

Entered at the Post Office of New York, N. Y., as Second Class Matter.
Copyright, 1908, by Munn & Co.
Published weekly by Munn & Co. at 361 Broadway, New York.
Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York

Scientific American, established 1845.
Scientific American Supplement, Vol. LXV., No. 1672.

NEW YORK, JANUARY 18, 1908.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

ADHESION SECTION NEAR SCHLUCHT PASSAGE AT FRENCH FRONTIER.

THE MOUNTAIN ELECTRIC RAILWAY TO THE SUMMIT OF THE ALTENBERG.—[SEE PAGE 40.]

THE ADVANCE IN MATERIAL FOR MACHINERY.

AN ACCOUNT OF THE NEW STEELS.

BY E. F. LAKE.

THE improvements made in the materials used in building all kinds of machinery have without doubt been greater in the past few years than in any period preceding this, and this improvement has covered the entire field of metallurgy.

By the addition of different alloys, steels have been given static strength that would have been considered impossible only a few years ago, and steels are being produced to-day in so many different grades and combinations of alloys that it is impossible to go into the details of their composition, strengths and uses without writing a large volume. While great progress has been made in the strength of steels and the consequent loads they will carry or the stresses they will stand, it is beginning to be realized that high static strengths do not always mean that the metal will withstand alternating and vibrational stresses or impact shocks; hence other alloys are being added that have doubled and in some cases more than doubled the steel's ability to withstand these dynamic tests.

The large variety of steels on the market and the cheapening in the cost of their production has practically abolished the use of wrought iron in the construction of machinery. It is seldom met with to-day and then only for some special purpose.

The methods and processes employed in the molding and melting of cast iron have been improved to such an extent that we see internal-combustion engine cylinder walls made ¼ of an inch thick, whereas it would have been considered suicidal but a few years ago to make them less than ½ inch thick. Brasses and bronzes have by the addition of new alloys and new processes in manufacture had their strengths and wearing qualities greatly increased.

With these improvements in the old metals some commercially new metals, such as aluminium, have come prominent and aided in the perfecting and widening of the scope of machinery in all lines of production.

To the layman, and for that matter to many machinists, cast iron is cast iron; but to those up in foundry practice and engineering there are probably as many qualities of cast iron as of any other metal, unless it be steel. Up to comparatively recent times iron and steel founding was carried out by rule of thumb, but scientific methods have now been introduced and all foundries of any size have laboratories in which the metals are analyzed and tested so that any desired quality of iron can be produced within certain limits.

Much of this improvement has been due to the perfection of the electric smelting furnace and its use in the production of rich ferro-alloys at a comparatively moderate price. Among those which are important to foundrymen might be mentioned spiegel, ferro-manganese, silicon-spiegel, ferro-silicon, ferro-chrome, ferro-phosphorus, ferro-aluminium, ferro-titanium, ferro-vanadium, and mixed alloys of the above elements.

These elements add different properties to cast iron, such as hardness and softness, while refining the grain, removing blow-holes and microscopic cracks, increasing the strength, lowering the sulphur and phosphorus contents, etc.

Ferro-manganese and spiegel are used more than any of the other elements in making cast iron, and differ only in that the former contains a high and the spiegel a low percentage of manganese. These are used both to harden and soften cast iron, and the results are obtained by a high or low percentage of manganese, which, however, varies with the amount of carbon as well as the sulphur in the iron; its work is largely governed by these. As an example of its hardening effect, one pound of ferro-manganese is put in the bottom of a ladle into which is tapped 300 pounds of cupola iron to produce the chill in car wheels.

Silicon-spiegel is closely allied to the foregoing, as it contains a considerable amount of manganese. The silicon increases the solubility of gases in the metal when solidifying, thus preventing honeycombing, and also has a softening effect which is further enhanced by the manganese, as this reduces the sulphur. Both are deoxidizers of considerable power.

Ferro-silicon tends to convert the carbon contents to a graphitic condition and so produce a soft casting. Some tests have shown that when added in the ladle a gain in transverse strength and deflection of 24 and 30 per cent respectively was made.

Ferro-chrome is a hardener, and is used where hard wearing properties are desired, as in cast iron piston rings.

Ferro-phosphorus makes iron very fluid when molten, and causes it to make a fine impression in the sand, and is therefore used to advantage in fine thin ornamental or artistic work where strength is not considered, as a high percentage of phosphorus makes iron very brittle.

Ferro-aluminium is used as a deoxidizer and thereby refines the grain; but very little of it should remain in the metal, as it is liable to remain suspended and thus cause a loss in strength by the lack of continuity of the metal.

Ferro-titanium acts as a deoxidizer, and combines with both oxygen and nitrogen, therefore aids in removing these gases and thereby produces sound castings. It increases the transverse strength and the hardness of the chill of cast iron.

Ferro-vanadium refines the grain and reduces the porosity of cast iron as well as increasing the breaking strength. Thus it is useful for such castings as valves and explosive-engine cylinders.

In the melting of iron the air or reverberatory furnace has made a large improvement in the quality turned out by the cupola; this is due in a great measure to the freedom of the air-furnace iron from slag, and also to the lower percentage of total carbon in the iron. Graphite crystals separate the grains of iron, thus reducing its strength; the larger and coarser these crystals are the greater will be the reduction. The air furnace tends to reduce these crystals; hence the iron is stronger than cupola iron. The ordinary cupola iron which would give a breaking strength of 22,000 pounds when melted in the cupola will show a strength of 32,000 pounds if melted in the air furnace; and the regular charcoal iron, cupola melted, which would show a strength of 30,000 pounds, is increased by air-furnace melting to 42,000 pounds per square inch.

Steel castings have been greatly improved by new methods of melting and the use of the many new alloys such as are mentioned above, with the result that many castings are now made as large as 8 x 10 feet with no section thicker than ¾ of an inch.

Of the melting methods might be mentioned the Tropenas converter, which by reason of the high temperatures attainable has enabled castings to be made of very delicate and intricate shapes. This, with the greater density of the castings caused by separating the molten metal from direct contact with the gases of the combustion materials and the addition of new alloys for strengths, has enabled the designer to substitute castings for many parts which were formerly forged; many of these castings can be forged, welded, machined, tempered and case-hardened as readily as other steels produced by the steelmakers.

Nickel steel has been successfully cast for a number of years in large castings for rolling-mill machinery, such as gears and pinions. It is now being cast in small castings for automobile parts. These castings have been used successfully for crank-shafts and connecting-rods on internal combustion engines and for front axles on automobiles as well as for numerous other parts.

Cast manganese steel is another of the late products of the steel foundry and shows some remarkable wearing qualities for machinery which has to stand the grinding wear of steel rails on curves and on ore and stone crushers.

Chrome steel is also being cast for work which requires a very hard steel that can be machined.

The line of demarkation between brass and bronze is so slight and liable to overlap itself that what one may call a brass another would call bronze; but if we consider only the common red and yellow brass, practically no improvement has been made in it, and it is used where no particular mechanical properties are required. If we class all the other combinations as bronzes, great progress has been made in increasing their mechanical properties. Among the more prominent of the bronzes which have been brought out in the last few years is manganese bronze; but a few who wish to differ from the ordinary mortal insist on calling it steel bronze. For many years attempts were made to strengthen brass by the addition of iron; but it is only in the last few years that this was successfully done, and it was accomplished by using manganese as the distributing agent. Aluminium is also added to make it pour easily, as it could not be cast in sand molds at all without a small percentage of aluminium.

Manganese bronze has nearly doubled the static strengths of other bronzes as well as raising the elongation and reduction of area which gives it good dynamic qualities. It is being used to a large extent for gears and has been used successfully for connecting rods on small explosive engines. It also gives good satisfaction for front axles on automobiles which have to withstand a large amount of vibrational and shock stresses.

Aluminium bronze is also one of the new products of the brass foundry which has increased the strengths of bronzes. In combination with a small percentage of nickel it gives a greater tensile strength and elastic limit than manganese bronze, but the nickel decreases the elongation and toughness of the metal. A straight 10 per cent aluminium bronze improves the strengths of the ordinary bronzes, but is not the equal of manganese bronze.

Tobin bronze is a special mixture for marine work, made to withstand the chemical action of salt water. Its tensile strength and elastic limit exceed that of manganese bronze, but it is not its equal for elongation and reduction of area.

Many secret and patented combinations of metal are being made for replacing bronze and brass, some of which show good results and others no better than the ordinary brands.

The phosphor bronzes and bearing metals have also been greatly improved in their wearing qualities and are fast taking the place of the babbitt metals which have held sway so long, although there are many places yet in which babbitt metals are the best to use.

Of the new metals which have been made a commercial success in the past few years, aluminium has by far surpassed any of them in regard to the amount used. This is due entirely to its weight, as it is not as strong as any of the other metals except cast iron, aluminium being about one-third of the weight of brass. It has been used extensively for casings on automobiles and may come into very prominent use for the much-talked-of flying machine.

The pure aluminium has a tensile strength of only 12,000 pounds per square inch, but alloys of copper or zinc or both raise this to over 20,000 pounds and the elastic limit to nearly the same figure without increasing its weight to any extent. If alloyed with from 2 to 8 per cent of nickel, a tensile strength of over 40,000 pounds is obtained; but the weight will be increased to a considerable extent, although even greater strength than this can be obtained and the weight kept below one-half that of cast iron or brass.

Aluminium stands next to copper as a conductor of electricity, which, with its non-staining and non-tarnishing properties, makes it suitable for the construction of fine instruments, electrical apparatus, cooking dishes, name plates, etc.

Aluminium rolled into sheets and bars shows about 25 per cent greater strengths than the cast metal; made into wire, the strength will be doubled.

Probably greater strides have been made in the improvement and production of high-grade steels than in any of the other materials used in building machinery.

Of the ordinary carbon steels little has been done except to improve the methods of production. These are manufactured in a large number of grades and might be classed according to their carbon contents.

Nickel steels are noted for their wide range of physical properties when submitted to different heat treatments. One piece that came under the writer's notice had its tensile strength changed from 88,000 to 226,000 pounds, its elastic limit from 62,000 to 226,000 pounds, its elongation from 28 per cent to 8 per cent and its reduction of area from 58 per cent to 11 per cent. It also has the ability to withstand shock stresses to a much greater degree than carbon steel and will stand oil tempering, although it will not stand local hardening very well if high in carbon.

Nickel steel can be obtained with any percentage of nickel up to 35 per cent except between 8 and 15 per cent, where there exists a zone of brittleness and the mechanical properties cannot be ascertained.

It crystallizes much less than carbon steel in case-hardening and therefore makes a better steel for that purpose, but the percentage of carbon that nickel steel contains has a good deal to do with its good qualities, and the boast that some make about using a 2 per cent nickel steel means nothing unless the carbon content is right; as for instance a steel containing 0.12 per cent of carbon and 2 per cent of nickel has a very high tensile strength and very little elongation, while a steel containing 0.9 per cent of carbon and 2

per cent of nickel has a high tensile strength and a great elongation.

Nickel steel in its various percentages is used for many parts of machinery at the present time, particularly for the moving parts that are subjected to strains and stresses.

One interesting peculiarity of this steel is that one containing 0.10 per cent of carbon and 7 per cent of nickel, when case-hardened and not followed by tempering, gives the same results as an ordinary steel which has been case-hardened and tempered.

Silicon increases the tensile strength of steel at the expense of the elastic limit and is generally used in small percentages. The greater the carbon content the lower will be the silicon. Silicon steels have a remarkable resistance to shock in the direction of lamination, practically no resistance in a direction perpendicular thereto and are extremely fibrous; hence they are used quite extensively for springs, especially leaf springs.

This steel has also been used to quite an extent for gears in automobile construction, but when so used it is necessary to make the fiber of the metal run in the right direction or the gears will not be as good as ordinary carbon-steel gears; but if the blanks are made in the form of forged rolls and not cut from bars, it is an excellent steel for gears.

A silicon steel containing from 1.2 per cent to 1.5 per cent of silicon and 0.45 per cent to 0.50 per cent of carbon will give a tensile strength of 125,000 pounds, an elastic limit of 76,000 pounds and an elongation of 16 per cent when in the annealed state. If heated to 1,550 degrees F. and quenched these become tensile strength 235,000 pounds, elastic limit 235,000 pounds and elongation of from 2 per cent to 0 per cent. If quenched at 1,550 degrees and reheated to 975 degrees these become tensile 192,000, elastic limit 172,000 and elongation 8 per cent. Steel containing 0.50 per cent carbon and 0.60 per cent tungsten shows a tensile strength of 125,000 pounds.

The general influence of chromium on steel is to increase the tensile strength and resistance to shock, by producing a mineral hardness and refining the grain. It makes a steel that is very difficult to machine or to work hot, but the above properties make it a valuable metal for armor plate and large guns. It is also used quite extensively for ball cups and races in ball and roller bearings. Owing to the tendency of chromium to oxidization and the formation of slag, the steel cannot be welded except with the aid of electricity or the acetylene blowpipe.

In combination with carbon and nickel or vanadium, or both, it makes without doubt the very best grade of steel known, whose static and dynamic strengths reach figures which were not thought of a very few years ago. The full value of nickel-chrome and vanadium-chrome steels is just beginning to be recognized for moving parts of machinery which have to withstand severe strains and where light weight is much desired.

Nickel or vanadium, especially vanadium, imparts properties to chrome steel which make it machine much easier, and it is said of vanadium-chrome steel that it can be machined as easily as a 0.40 per cent carbon steel.

Vanadium is the latest element to be alloyed with steel and is used in very small doses, less than 0.30 per cent sufficing for nearly all purposes. Its most successful use has been in the form of the quaternary steels, as it acts as a physic on the other ingredients and greatly intensifies the static strengthening powers and toughens the micro-constituent ferrite, which shows a close interlocking granular formation.

Vanadium produces soundness mechanically as well as chemically, owing to the vanadium ferrites having a much higher degree of molecular cohesion than plain ferrites, while some other alloys, such for instance as nickel, have a lower cohesion. It also retards the segregation of the carbides, which makes the steel easily tempered and renders possible the natural formation of the "sorbitic" structure, which is necessary in metals that have to resist wear and erosion. Vanadium steel also has self-lubricating properties to a greater extent than other steels, hence is more valuable for shafts running in parallel bearings and for gears.

The above properties have raised the dynamic properties of steel far above those obtained by any other alloy and at the same time have retained the high static strengths of the best alloyed steels as well as making the steel as easily machined, forged, tempered and case-hardened as any of the common brands of steel.

This makes a steel that is suitable for the highest grades of machinery and for those moving parts which have to withstand the severest of strains and stresses, such as the crank-shafts and connecting-rods of explosive engines.

Tungsten reacts on steel somewhat as carbon does, that is, increasing its hardness; but it has been proved that weight for weight carbon is superior in this respect, although a tungsten-chromium steel is capable of becoming very hard and tough when quenched from a glowing white heat by dipping in a bath of oil, a method of tempering that would ruin ordinary tool steel. Tungsten steel is only slightly extensible and will not stand shock. Although less brittle in the direction perpendicular to the fiber than silicon steel, it does not appear to be superior to the latter; nevertheless it has been used in the manufacture of springs.

Tungsten, however, is not used in steel to any extent for machinery construction, but is one of the principal ingredients of high-grade tool steels.

Other alloys, such as molybdenum, t[illegible] cobalt, arsenic, wolfram, and aluminium, are used in steels for some special purposes, but with the exception of aluminium are not used to any extent. Aluminium, however, has become quite a factor in the production of steel in the last few years, and a small percentage of it is used in many of the high-grade steels as a deoxidizer to refine the grain; but when analyzed the metal should show only a trace, as it should oxidize out.—American Machinist.

LUBRICATION OF ENGINE VALVES.

DEFECTS OF THE PRESENT METHOD AND THEIR REMEDY.

A CLOSE study of the present method of lubricating the internal working parts of the steam engine cylinder reveals a practice which for economy of oil is far from good. The oil is put into the steam passages and allowed to vaporize and, more or less, to volatilize and travel along with the current of steam. The steam coming in contact with the walls and internal parts deposits at least part of its oil burden, and the steam which does not come in contact with anything carries its oil out of the cylinder and then wastes it.

A little thought shows that but a small percentage of the total steam flowing through must come in contact with the faces of the valves and working parts, which means that a large part of the oil fed into the cylinder never fulfills its mission. When superheated steam is used the lubrication obtained from condensation can no longer be depended upon, and thus more oil will be required than when saturated steam is used.

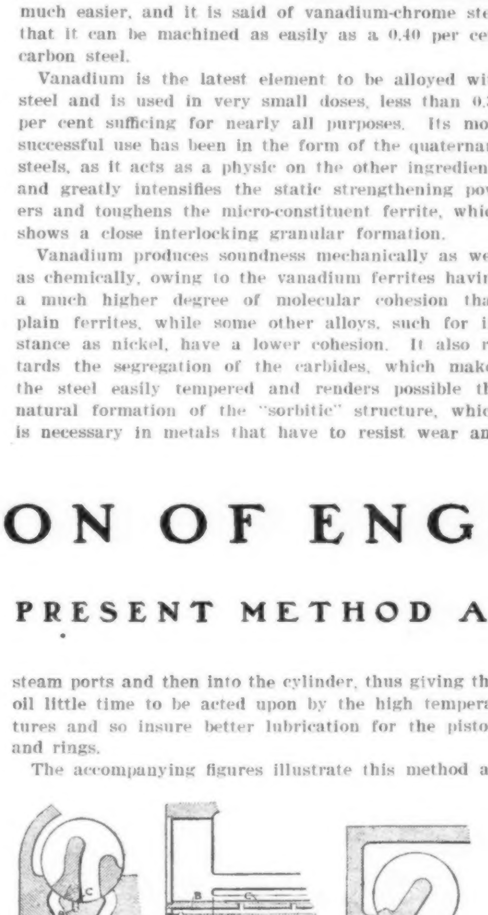
To obtain maximum economy in the use of any material, the material must be put, in the proper quantity, where it is most required, or where it will do the most good or save the most money. Applying this to valve lubrication means that the oil or lubricant must be put on the seat of the valve or between the valve and its seat, this being the place where the oil is required; not all over the valve and its connections, where it does no good.

Now it is evident (says a writer in Power) that the pressure on the oil, or the oil pressure per square inch between two bearing surfaces, is equal to the pressure per square inch on the bearing, due to the weight or load the bearing carries. This being the case, the pressure required to force the oil under or between the bearing surfaces would be slightly in excess of the load per square inch on the bearing; the excess pressure being that required to overcome hydraulic friction, check valves, etc.

In the case of the engine with a balanced valve, the oil pressure required would be slightly in excess of the steam pressure the engine works with, or within the range of the ordinary mechanically-operated oil pump now used to force oil into the steam space. Judging from the construction of some of these pumps, they are able to operate satisfactorily against a pressure a few times greater than the average steam pressure now used, thus being able to force oil under partly balanced valves and Corliss valves. This method of lubrication would insure the valves riding on a film of oil that was neither atomized nor volatilized, no matter if high-pressure or superheated steam were used.

From the valves the oil would pass directly into the steam ports and then into the cylinder, thus giving the oil little time to be acted upon by the high temperatures and so insure better lubrication for the piston and rings.

The accompanying figures illustrate this method as



LUBRICATION OF CORLISS VALVES.

applied to Corliss valves as generally made. The oil is fed through the pipe *A* into the passage *B* and then into the groove *C*, running nearly the full length of the valve seat. To insure the best results the oil groove *C* should at no time during the working of the valve be uncovered and thus expose the oil to the action of the steam. This may require slight alterations in some Corliss valves as now designed, and in most valves of the gridiron and slide types, but any necessary changes required to adopt this system of oiling would probably be more than paid for in the reduction of friction and saving of oil.

In some cases the cutting of the groove *C* in the valve seat may be rather difficult, especially in small Corliss valves, but the oil could be forced under the end of the valve and carried along the valve seat by means of a groove cut in the face of the valve. This scheme would undoubtedly work as well as the one with the groove in the seat, provided the width of the seat and motion of the valve were so proportioned as to keep the groove in the valve covered.—The Practical Engineer.

Turners' Varnish.—(1) 2 parts of gum elemi, 10 parts of bleached shellac, 2 parts turpentine, 30 parts alcohol. (2) 25 parts of gum lac, 5 parts of gum elemi, 100 parts of 96 per cent alcohol, 300 parts of warmed Venice turpentine, [illegible] 200 parts of purified gum sandarac, 60 parts of mastic, 8 parts of camphor, 500 parts of 96 per cent alcohol.

THE COST OF POWER PRODUCTION.

PROF. CHARLES E. LUCKE, of Columbia University, having made a study of the subject of the comparative cost of various methods of producing power, with special reference to electric power stations, has collected some figures which he presented in a paper read before the American Electro-chemical Society. He compared water-power development, oil engines, gas engines and producers, and steam engines, assuming a 24-hour continuous load in each case. In the case of the oil engines, 250-horse-power units coupled to 160-kilowatt generators were taken for example, and the station was supposed to contain six such units. As typical of steam engines, a plant of six 5,000-kilowatt units was selected, while for gas engines a station containing six 1,000-horse-power units driving 600-kilowatt generators was chosen. Steam turbines were not considered in the steam plant, the author saying that the net result would not be very different from that of the reciprocating engines. Under these assumed conditions the comparison of power cost was figured as follows:

Water-power—First cost per kilowatt rating, $75 to $200; total power cost per kilowatt-year, $8.50 to $25.

Oil Engines—First cost, similarly, $217; cost of power per kilowatt-year, $78.64.

Gas Engines and Producers—First cost, $270; annual cost of power per kilowatt-year, $65.54.

Steam Engines—First cost, $110 to $150; power cost per kilowatt-year, $85.50 to $97.50.

The hydro-electric plant shows up very favorably, although it is to be noted that the cost of transmission is not included. The author thinks it likely that gas power will be cheaper than steam when the load factor is high, and that the difference will be greater as the cost of coal is greater. The figures given, of course, are only correct in a general way, "for," says the author of the paper, "the determination of power costs is not only a question of geographical location, a question of the generating system, a question of the size of the apparatus, a question of the perfection of its design, a question of the load location, but it is also a question of accounting, and the engineer engaged upon a question of this sort must not only be an engineer, but something of a financier and an accountant."—Western Electrician.

THE OPERATION AND CARE OF INJECTORS.

A PRACTICAL DISCUSSION OF THE LEADING TYPES, EXPLAINING THEIR ACTION AND THE MOST APPROVED METHODS OF CONNECTING.

BY W. H. WAKEMAN.

INJECTORS are now regarded as more reliable as boiler feeders than ever before in their history, but there are numerous points to be learned and remembered concerning their operation and care, neglect of which will surely result in their failure when they are most needed, and such failure will probably cause an

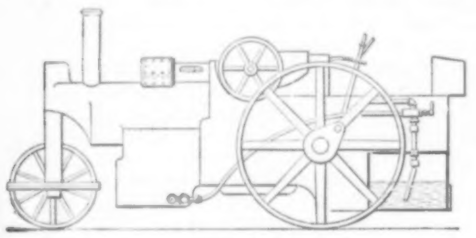
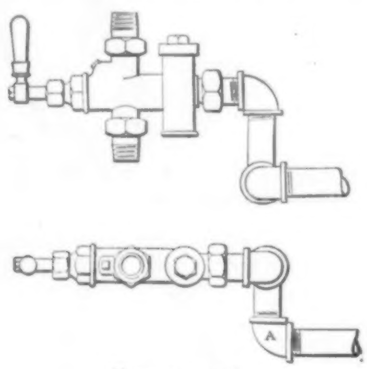


FIG. 1.

annoying and expensive shut-down. This applies alike to large and small plants.

Fig. 1 shows an ordinary road roller fitted with a water tank located under the engineer's position as he stands to fire his boiler. Such a tank must have a tight cover in order to exclude pieces of coal and other extraneous matter that are not wanted in an injector. This of course makes it impossible for the engineer



FIGS. 2 AND 3.

to see the suction pipe of his injector, therefore he cannot easily tell whether it is in good condition. As a rule, such a pipe will not become deranged after it is once put in good order, but in this case it was necessary to repair the tank, and the suction pipe had to be removed for this purpose. Such a tank is small and not very convenient to work in, hence when the pipe was replaced, it was not screwed into the coupling properly, but was caught at an angle and not

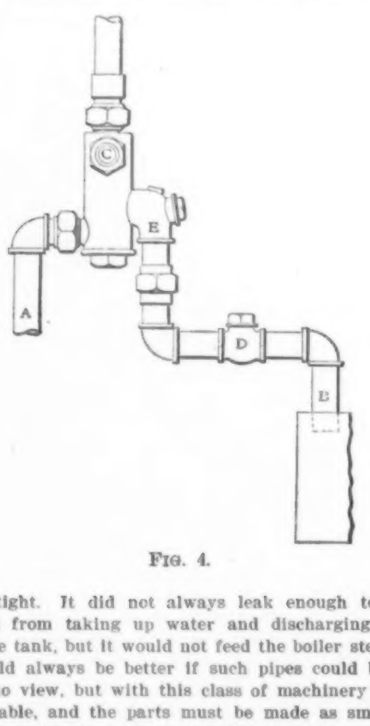


FIG. 4.

made tight. It did not always leak enough to prevent it from taking up water and discharging back into the tank, but it would not feed the boiler steadily. It would always be better if such pipes could be exposed to view, but with this class of machinery space is valuable, and the parts must be made as small as possible and located closely together in order to bring the whole within narrow limits, because the entire outfit must be in shape to be readily transported from place to place.

Fig. 2 illustrates an ordinary injector without connections, except a small part of the discharge pipe. This is presented as I found it, with three ells located in a distance of less than one foot. Fig. 3 is a plan view of the same injector. Let us see what the objections are to this arrangement of fittings. When water is discharged by an injector into the pipe which conveys it to the boiler, it travels rapidly, hence when it strikes a short turn at right angles, as it does when an ordinary ell is used, much of the momentum is taken up by changing the direction in which the body of water is moving. In this case one change is made, in turning the water from a horizontal to a vertical direction (see Fig. 2), and as soon as this change is made it strikes another ell which turns it back to a horizontal motion, after which it passes through another ell, *A*, Fig. 3, that turns it sharply to the right.

In this connection it must be remembered that an

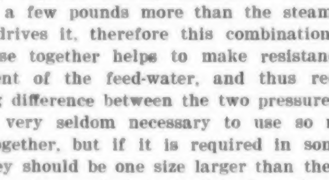


FIG. 5.

ordinary injector is only intended to deliver water against a few pounds more than the steam pressure which drives it, therefore this combination of three ells close together helps to make resistance to the movement of the feed-water, and thus reduces the working difference between the two pressures.

It is very seldom necessary to use so many ells close together, but if it is required in some special case they should be one size larger than the feed-pipe demands, thus reducing friction by allowing more room for the turns. In the case under consideration they were made one size smaller than the injector fittings which, of course, increased the friction. This particular case is mentioned in detail because it gives the reader a better idea of the objectionable features, than to lay down general rules and directions to be followed. If fittings for such service were made longer and given easy curves instead of such sharp turns, the result would be more satisfactory. To overcome this objection the plan of bending the pipes is adopted, but this cannot be done in all cases, and unless care is taken to do the job well the pipe will be flattened, which will reduce its capacity more than the sharp turns caused by ordinary ells. If the pipe to be bent is filled with sand and a coupling with a plug in it put on each end, it will assist in keeping the pipe round.

AUTOMATIC RE-STARTING INJECTORS.

A few weeks ago I had some trouble with an automatic re-starting injector that proved interesting. This

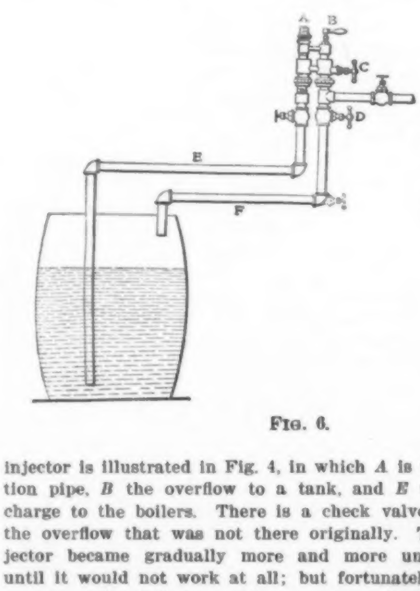


FIG. 6.

injector is illustrated in Fig. 4, in which *A* is the suction pipe, *B* the overflow to a tank, and *E* the discharge to the boilers. There is a check valve, *D*, in the overflow that was not there originally. This injector became gradually more and more unreliable until it would not work at all; but fortunately there are two other injectors and two pumps that can be used. When steam is turned on to this injector, it draws water through *A* and allows it to overflow until a valve in the feed-pipe is opened, when water goes into the boilers. The overflow valve *E* is nothing more than a check-valve opening outward for the discharge of water, but when the injector is feeding the boilers this valve closes to prevent air from entering.

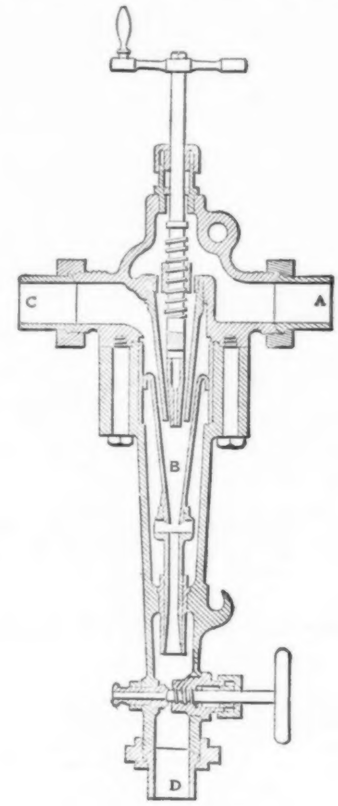


FIG. 8.

About twelve years of service caused this valve to leak, but owing to the fact that it draws in air instead of allowing water to drip into the tank, it did not attract attention to the cause of failure.

The cap of this overflow valve *E* was removed, showing that the hinged disk, Fig. 5, was made to receive a screw-driver for the purpose of turning it when it needed to be "ground in," as it certainly did at the time referred to. A little fine emery, or some of the dust found in the trough under the grindstone, if put between the surfaces, will grind off the high spots and tend to make a tight joint. This joint I have already mentioned, but when using the screw-driver it is better to turn it, say, one-quarter of a revolution in one direction, and then turn it back again, rather than to

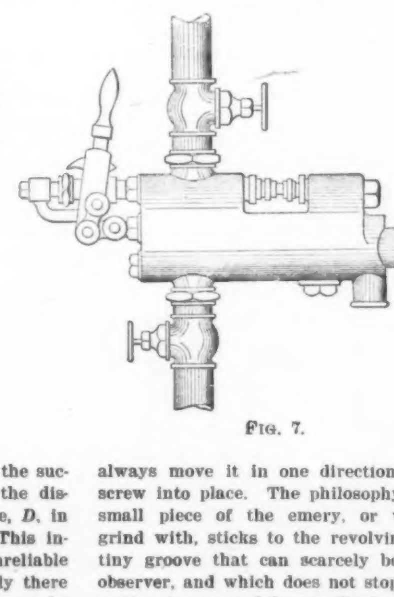


FIG. 7.

always move it in one direction, as when turning a screw into place. The philosophy of this is that if a small piece of the emery, or whatever is used to grind with, sticks to the revolving disk, it will cut a tiny groove that can scarcely be seen by the casual observer, and which does not stop the leak; but if the motion is reversed frequently, better results are usual-

ly secured. In this case it was difficult to secure an absolutely air-tight joint, even with good facilities for doing the work, therefore I put another check-valve in the pipe, as shown at *D*. It is fitted with a hard-rubber disk which was not tight when first tried, and I did not expect it to be, because these disks are comparatively rough when new, whether the entire valve is new, or only a worn-out disk has been replaced by a better one. These valves, and all other kinds having a hard-rubber disk, are intended for use on steam pipes, or very hot water pipes, consequently the heat softens the disk and makes it fit the seat. In this case hot water was run through the overflow pipe for this purpose, until the disk was well heated.

There is another way in which a leak in the overflow may be prevented from causing trouble, and that is by carrying the end of the pipe below the water line in the tank. In this case water is drawn in through the leak and goes to the boiler, doing no harm. When the injector is started the overflow pipe is heated by escaping water, and if this pipe gradually assumes the temperature of the room in which it is located, it shows that no leak exists in it; but if it becomes colder at once, it indicates the passage of water, as already mentioned.

THE INSPIRATOR.

Fig. 6 illustrates a very different kind of an injector, known as an inspirator. The question concerning the difference between an injector and an inspirator is frequently asked by steam users and engineers, and in reply I would say that there is no difference, as the inspirator is one kind of an injector. All injectors may be divided into two classes, namely, the single- and the double-tube kinds. Fig. 4 illustrates the former, as there is but one set of tubes in it, which must do both the lifting and the forcing. Fig. 6 illustrates the latter, as it contains two sets of tubes. When steam is admitted at *A* the valve *B* is closed, but *C* and *D* are open; therefore water is drawn up through the suction pipe *E* and is returned through *F* to the barrel or tank. When this has circulated long enough to insure dry steam coming to the inspirator, close *C*, the effect of which is to decrease the lifting power, and open *B*, thus admitting more steam to the forcing side and raising the temperature of the escaping water. Do not let this continue too long, or it may heat the water in the barrel until the inspirator will not take it; for it should be remembered that the incoming water must be cool enough to condense the steam, or else the machine will not deliver water against boiler pressure. Slowly close *D* and the water will go into the boilers, provided that all valves in the feed-pipe line are open. I have seen many failures to start an inspirator simply because the valve *D* was closed with a jerk that brought a heavy back pressure to bear for an instant, but that was long enough to "break the jet" of water, making it necessary to start it over again.

After an inspirator has been used for a long time, the valve *D* may leak, thus allowing more or less of the water to flow back into the barrel. It is quite possible for the capacity of the machine to be much reduced in this way, which also causes a loss of heat that is not good practice. The valve *D* should be "ground in" and made tight, or another valve with a hard-rubber disk may be added, as shown by the dotted lines. Of course it will be understood that this is not a defect that is peculiar to an inspirator, as any other form of injector may become worn in the same way and require similar repairs.

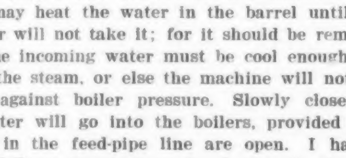


FIG. 10.

I have another kind of double-tube injector that gives very good results in practice. It is illustrated in Fig. 7. Neither barrel nor tank is used in this case, as water under pressure is supplied directly to the injector. The practical difference between these two injectors, both of which are fitted with double tubes, is that when handling Fig. 6 it is necessary to adjust each valve separately; but with Fig. 7 they are connected to one lever, hence when this is moved, it takes them all together, which is a very convenient arrangement, provided it is in perfect order; for in this case all valves must reach their limit of movement at the same time or else the machine will not deliver water to the boilers. If the movement is not equal, there is no convenient way for compelling such action.

ACTION OF THE INJECTOR.

Having presented many practical points concerning the operation, care, and repairing of injectors, it is in order to explain the action of this useful device, as every man who uses an injector should understand the theory of its action; for in this, as well as in other branches of steam engineering, practice and theory are closely allied, and the man who attempts to rely on one and ignore the other, although he may attain a certain degree of success, will come short of that full measure of perfection that belongs to every man who fully masters the details of any complicated process pertaining to modern machinery.

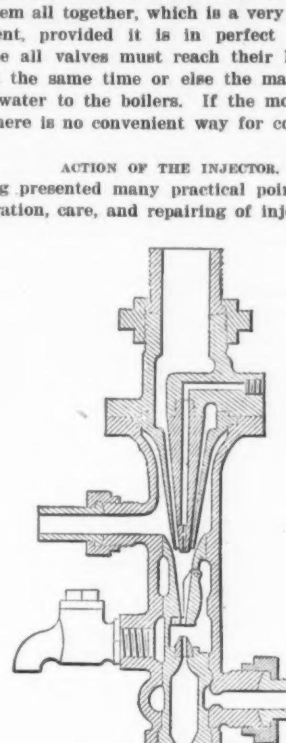


FIG. 9.

In California there are several noted water powers in which the head is several hundred feet, giving a very high pressure to the water where it is used on water-wheels. If there is a slight leak in the pipe which conveys it down into the valley, water comes out in a thin but very powerful stream, or jet, and where such a leak is discovered it is very natural for an inexperienced person to let the water play upon his hand, but one such experience is usually enough, as the great force due to such a high pressure is sufficient to peel the skin and flesh from the hand as if it were done by a steel knife. This action is of course due to the momentum of the body of water, caused by pressure behind it, but after it has escaped from the pipe, pressure can no longer control it, and its action is due wholly to momentum. Is it not easy to imagine such a jet of water as going into another pipe under pressure in direct opposition to that pressure?

When steam at 120 pounds pressure enters an injector under perfect conditions, its velocity when expanded is more than 1,400 feet per second. If it enters a vacuum of 22 inches under similar conditions, this great velocity is increased to 3,400 feet per second. While moving at this high speed it strikes a body of motionless water and is at once condensed, after a portion of the momentum has been imparted to the water in the process. The natural consequence is that a comparatively heavy body of water is given momentum enough to make it enter the boiler against full pressure.

Fig. 8 illustrates the Giffard injector in one of its earlier forms. Steam enters at *A* and is discharged through the contracted nozzle shown into the chamber *B*. Water enters at *C*, and coming into contact with the steam in the chamber *B* is given momentum as above described. Passing down through *D* it enters the feed-pipe and is thence delivered to the boiler. I have been told several times that if a tallow candle is put into the barrel of a gun, with a charge of powder behind it, the candle can be driven through a pine board when the gun is discharged. I have never tried this experiment, but it seems reasonable, and if it can be done it is due to the great velocity of the candle when it strikes the board, and the momentum so gained is what causes it to pierce the harder substance; therefore it ought not to be difficult to understand how an injector can project a column of water against boiler pressure.

In order to show that the pressure of steam has little bearing on the subject, I call attention to Fig. 9, which is an exhaust-steam injector. It is not necessary to put a back-pressure valve on the exhaust pipe in order to create pressure to run an injector of this kind, as steam is taken at atmospheric pressure and nothing more is needed unless the boiler pressure exceeds 75 pounds, and even then only a small jet of live steam is required. This is sufficient to feed the boiler when the engine is shut down, which is very convenient where the work to be done does not require power every hour in the day.

The condensation of a comparatively large volume of steam creates a vacuum into which the water to be fed rushes with great speed and thus the required momentum is secured.

While the exhaust-steam injector does not require pressure for its operation, it does need a good supply of steam, hence the piping must be correctly arranged, or it will not work well. Fig. 10 illustrates a defective plan for this work, as it shows a vertical exhaust pipe fitted with an ordinary tee. Of course some of the steam will go to the injector even with this arrangement, but it will not get enough to secure positive operation, and I have seen one that would not work at all; but when the piping was changed to the plan shown in Fig. 11, it worked perfectly. It is not hard to see why this worked better than before, as all of the steam that can get into the injector pipe will go there, and what cannot find its way here must turn and go out of the free exhaust outlet. As the steam fitter in this case could not collect pay for the work done in piping it up as shown in Fig. 10, he had to change it to Fig. 11 at his own expense. This should be a warning to both steam users and steam fitters, because such blunders always prove expensive to both.—Power.

PROCESS FOR NON-INFLAMMABLE CELLULOID.

A NEW process for making celluloid non-inflammable, devised by Pascal Marino, has lately appeared in Europe, and although it may seem somewhat complicated, it is easy to carry out in practice, and is claimed to give very good results. Ordinary celluloid is dissolved in acetone in a closed vessel; other solvents can be used, such as wood spirit, acetic acid mixed with acetic anhydride and alcohol, etc. The solution must not be too fluid nor too viscous. In the first case we expose it to the air, and in the second we add more of the solvent. We then prepare separately the following liquid: In acetic acid is dissolved one or more mineral salts which are insoluble in water or alcohol. The solution contains three parts of salt to ten or fifteen parts acid, and is filtered. Some of the salts which answer to the above are hydroxide of aluminium, iodide of aluminium, basic calcium phosphate, chromic oxide and others. The first of these salts and also phosphate of barium and some others give no color to the product, and the incombustible celluloid remains colorless as usual. With chromate of barium we have a straw color, while a pearl gray hue is obtained with a mixture of phosphate of cobalt and ferrous phosphate. To the solution of such salts we add tetrachloride of carbon, which is colorless and insoluble in water, using 3.5 parts of it to 100 parts of celluloid. The mixture is well made and we add also a small amount of tri-chlor-nitro methane (an incombustible liquid), to the extent of 3 to 5 parts per 100 of celluloid. Such mixture is then added to the celluloid solution mentioned above and intimately mixed in a closed vessel, allowing it to stand for ten hours. We then add a small amount of formaldehyde and well agitate in the closed vessel, leaving it again under the action of the formaldehyde vapors for eight hours. This latter product has the effect of agglomerating the celluloid in the form of a compact mass which floats upon the surface of the liquid. After drying the celluloid paste it is then shaped in molds as desired. The resulting celluloid is non-combustible, which gives it a great advantage, and at the same time has not lost its strength nor elasticity.

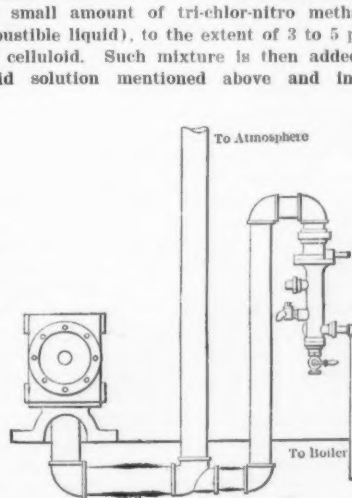


FIG. 11.

ELEMENTS OF ELECTRICAL ENGINEERING.—IX.

MOTORS FOR TRACTION PURPOSES.

BY A. E. WATSON, E.E., PH.D., ASSISTANT PROFESSOR OF PHYSICS IN BROWN UNIVERSITY.

Continued from Supplement No. 1670, page 7.

No application of electricity has made greater demands upon the engineer than that of railroad operation. The manifest inadequacy and expense of horse car traffic gave all the stimulus to invention and ingenuity that was desired. Perhaps, indeed, the early experimenters were a little over-sanguine in their expectations; certain it was that they underestimated some of the difficulties to be encountered, and many a severe setback was suffered and heavy cost incurred when cars were actually put into regular use. However defective the early car equipments may have been, this is certain, that no other means of street car propulsion has been able to make as economical a showing, and some other motive powers, such as steam, gasoline, and compressed air, have suffered pitiful deaths. Twenty-five or more years ago, an electric motor was looked upon as a delicate instrument, operative only under most favorable conditions, such as exclusion from dust and moisture, and kept under the careful scrutiny of a trained attendant. Especially was the commutator an object of tender solicitude, some users going so far as to try to inclose it and its brushes in a glass cage.

Dust and moisture, it is true, have proved the great "bugaboos" of electrical machinery, but with modern methods of vacuum drying and application of waterproof paints, combined with the insulating properties of mica, these militant factors are quite conquered. Consisting of but one revolving part and two sliding contacts, noiseless, and capable of a wide variation in speed, the electric motor offers a simplicity of construction that is quite beyond the imitation of any devices that involve reciprocating motions. The electric motors of a street car have thoroughly demonstrated their efficiency and reliability of operation. Even with due allowance for inevitable and desirable improvements in some matters of detail, especially in connection with the substitution of electricity for steam, for heavy and long distance railroading, electric traction systems must be regarded as one of the most perfect results in the field of successful engineering.

The demands of street car traffic require motors of powerful starting effort, or "torque," wide variation of speed, economical operation over a long range of power, and sensitive control. Mechanically, the motors must be as light as possible, protected from outside influences, and be of such general rugged construction that the jolting over joints in rails shall not dislocate the windings; even though run continuously for many hours a day, there should be no necessity for frequent examination and adjustments. In the early days of electric roads, some attempts were made to apply shunt-wound motors to this work; the armature was kept continuously running, like the modern practice with gasoline engines in automobiles, with variable gears or friction clutches for transmitting the power to the car axles; though such a motor might show a slightly higher average efficiency than the series-wound motors now commonly employed, the noise and weaknesses of these intermediate devices rendered their use impractical. Even with the other sort of motors, various schemes to permit flexible mounting upon the truck or to allow one motor to drive two axles, through the medium of bevel gears or sprocket chains, have been exhaustively tried and found wanting. Simple straight gearing, originally, in Sprague's celebrated Richmond, Va., road, only a single reduction, then for years, double reduction, now under more auspicious circumstances, single reduction again, is the only sort that receives recognition. Indeed some locomotives have electric motors mounted directly on the axles, thereby entirely dispensing with gearing, but slow speed armatures are necessarily large and heavy, involving the use of correspondingly large field magnets, and it is doubtful if room can be found for such constructions under ordinary street cars. With the geared sort there is the valuable convenience of being able readily to separate a motor from the axle, for repairs, without the awkwardness or undesirability of removing a wheel.

A diagrammatic representation of a series-wound motor is given in Fig. 34. The significance of the word "series" is that all the current that passes through the winding on the revolving armature passes also around the coils or the field magnet, that is, the two essential portions of the motor, field and armature, are electrically connected in series in a single circuit. If current arrives, as shown, at the bottom brush, it will pass through the armature winding, out at the upper brush, then around the two limbs of the field magnet, in opposite directions, thereby producing the desired N and S poles. The reason why a motor of this class is eminently fitted for traction work is that it inherently is a variable speed device, and that its starting torque varies closely as the square of the current. This latter characteristic is important for enabling a start to be made under heavy load; torque can be expressed numerically as the product of the

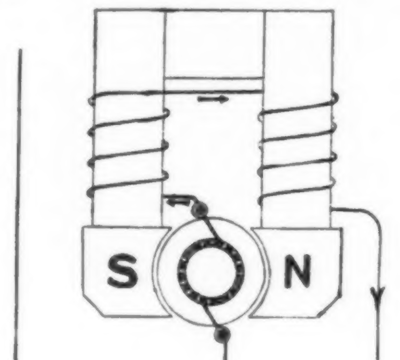


Fig. 34.—Diagrammatic Representation of a Series-Wound Motor.

number of lines of force of the field magnet by the current in the armature conductors, therefore, within the limits of saturation, doubling the main current will double both the factors, hence quadruple the torque. With light loads, the current of course is less, and this reduced value so deprives the field magnet of strength that the speed of rotation must needs be high in order that the counter electromotive force may still be approximately equal to the impressed value. A car motor will then automatically slow as a grade is approached, and acquire the necessary torque to do the work without demanding an undue amount of current; then, when again on a level, it will accelerate in speed, and reduce the consumption.

One point is rather perplexing to general readers, and that is, why such strong motors need to be adopted for car propulsion. Two horses were once regarded as sufficient for the purpose, with maybe an extra one for assisting at grades, or two extra ones in bad weather. Why therefore were two 7½ horse-power electric motors found inadequate for a single car, and then two of 10 horse-power, each in turn found to be too small, until the 15-horse-power size became standard? The answer is found in the combined factors, that at the moment of starting, a horse exerts considerably more than a normal horse-power; that the cars are much heavier than any ever attached to horses; that the electric car must have reserve power

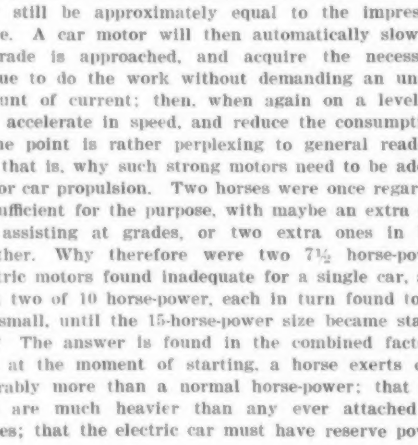


Fig. 35.—G. E. 800 Railway Motor.

equal to any emergency, such as the breaking down of one of its motors, and the transference of the entire load to the other, or the necessity of hauling a "trailer," or of helping a disabled car. Further, much more rapid accelerations and running speeds are adopted than would ever have been possible with horse power. The better to meet the exacting conditions of quick schedules, 25 horse-power motors are now regarded as none too large for two-motor equipments, or four of 15 horse-power each for double-truck cars. Motors of 50, 75, and even 100 horse-power are used on elevated roads.

The first car motors were copied from the stationary types; their windings, commutators and gears were wholly unprotected from water and dirt; the armature cores were of the smooth core variety, whereby the windings were readily loosened and ruined. It is certainly suggestive of the high cost of horse flesh that even under such adverse pioneer conditions, electric railroads were all able to show a marked economy of operation; even cable roads suffered in comparison of earning power, to say nothing of their serious mechanical handicaps. These early motors had one qualification that may possibly have been their salvation—they were well ventilated, and therefore capable of momentary heavy overloads. One requirement was recognized and met at the start, that the brushes should be fixed in one position, independent of the load or the direction of rotation of the armature. Strong field magnets and radially-pointing carbon brushes have been of inestimable value in maintaining sparkless commutation under these exacting conditions. A generator in a station can receive some adjustment in the position of its brushes, but the ever-changing loads and general inaccessibility of the car motor debar it from receiving any such attention. As a substantial help in providing sparkless commutation, the armature reactions are minimized by using long and slender teeth, highly saturated with magnetism by virtue of the field winding, therefore incapable of serious alteration by the weaker magneto-motive force of the armature winding.

When the double reduction of gears was employed, the armature made from nine to twelve revolutions for every one of the axle, and the high armature speeds together with the uncovered gears made the operation rather noisy. The first effective motors with only a single reduction in gearing were brought out in about 1891; with the armature making only about four and three-quarters turns to one of the axle, and the casing-in and effective lubrication of the gears, almost complete suppression of noise from this source was obtained. At the same time, some gain was made in protecting the motors from water by setting them in wrought-iron pans, but courage was lacking to keep out the dirt at the expense of ventilation. Another step consisted in making the lower half of the field magnet its own pan, with the upper half less open than formerly. A novelty in the construction of this first "water-proof" motor, as it was called, was the adoption of a single field spool, the saving in room thereby effected allowing the armature to be eighteen inches in diameter. Short axial length and rugged winding were secured by use of a toothed ring core. An innovation that marked a permanent change in the construction of railway motors was the adoption, at this time, by the Westinghouse Company, of four-pole field magnets and toothed drum armatures with series or wave windings. This sort of winding that permits the use of four or more poles, yet only two brushes, was described in Chapter V.

In consequence of the difficulty of access to a car motor this capability of the series type of multipolar armature winding, to dispense with brushes at all other than two places on the commutator, is greatly appreciated, and allows simplification of the mechanical design. With a four-pole field, brushes will therefore be needed at two places, not diametrically opposite, but only one-quarter of a circumference, or 90 deg. apart. Some motors are designed to be reached through a trap in the car floor, others from a pit in a repair station; in either case, the removal of a cover exposes both brushes; were brushes needed in all four places, provision for opening the motor at both top and bottom would be unavoidable.

At the time of the consolidation of the Thomson-Houston and Edison Electric companies in 1892, a new design of motor was made in Lynn, Mass.; with 14 teeth in the armature pinion, 67 in the axle gear, it would normally exert through 33-inch car-wheels a draw-bar pull of 800 pounds. To commemorate the new company, it was named the "General Electric 800," or for short, "G. E. 800." In horse-power, it would correspond to a rating of about twenty-five. Though not now built, it became a very popular motor and is still regarded by many users as one of the best ever put on the market. A view of one is given in Fig. 35, showing the upper half of field magnet hinged up to allow inspection of armature. Two field

spools were employed, one each at top and bottom, but so connected in opposition to each other as to produce "salient" poles in the iron within, but two of the other polarity in projections of equal arcs in the portion of iron midway; these latter poles are of the "consequent" sort, and are divided in their middle by the joint in the halves of the field magnet casting. In the view these castings appear very thin and light, but they are made of soft steel, nearly as good for magnetic purposes as wrought iron. The pinion is shown on the end of the armature shaft, and the lower half of the gear casing is in place; but the axle gear and the axle itself are omitted, though the bearings for it are clearly given. In the left-hand end of the upper field magnet casting may be seen the two brush holders, attached to a wooden block in such a manner that when lowered into place contacts will be made at points 90 deg. apart. The frame entirely incloses the windings, access to commutator and brushes being allowed by removing a small iron cover. It was the experience gained with this motor that demonstrated the entire feasibility of the inclosed type, now commonly demanded by railways.

With the inevitable refinement of construction and economy of materials resulting from sharp competition, modifications of design have gradually been introduced, and considerable uniformity exists among the different manufacturers; in fact, in the United States only the General Electric and Westinghouse companies now make railway motors, and they follow each other's designs to such an extent that it is not easy to discover any difference whatever. Different sizes may have peculiarities, but those designed for the same class of service are practically identical. One valuable economy of size of armature has been attained by the device of using only one-third as many slots and then putting in three coils per slot, the commutator still having the full number of segments. It will be understood that since one terminal of the circuit for a railroad motor is already grounded, the full difference of potential is exerted between every coil and the iron core, and that every slot of the armature must have equal amounts of insulation, usually about one-sixteenth of an inch thickness of mica, or some composite substitute. The difference of potential between two adjacent coils, however, is quite small, and comparatively thin insulation will suffice; therefore the practice of placing three coils in one slot saves nearly four thicknesses of mica out of the former six, or about one-quarter of an inch on the circumference, and with thirty-five such groups of coils, a total saving of nearly 9 inches, or a reduction in diameter of nearly 3 inches. On a diameter of 16 inches, as was the case of the G. E. 800 armature, this saving is seen to be considerable, and all the more worth having because of the added ability to make the entire field magnet smaller and lighter.

Such prominent teeth would result in the production of wasteful eddy currents being set up and maintained in solid pole pieces, consequently the necessity is involved of building them up of sheet iron, as is now very common with stationary dynamos. This extra expense is fully justified by the resulting ability to give the pole pieces and cores the proper shape to minimize weight and secure sparkless commutation. These laminations, when riveted together, form sufficiently rigid masses to allow for being bolted in place against their seats in the field frame by any one of several methods.

In order to secure proper alinement and meshing of the gears, the car axles pass through suitable bearings on the motor, and assume about one-half of the weight; the other half of the motor weight is ordinarily suspended on a flexible cross bar, or upon cushion springs, and at the moments of starting and stopping some degree of flexibility is imparted to the mechanism. Further, some of the jars and shocks due to inequalities of the roadbed are thereby a little softened before delivery to the motors. More complicated suspensions have been designed, in which the motors are nearly suspended from their centers of gravity, resulting in qualities of easy riding that are very agreeable to the passenger and conducive to long life for the machinery. The ordinary suspension is shown in Fig. 36, representing a modern four-pole wholly inclosed motor in position on the axle.

The application of electricity to heavy railroading, i. e., as a substitute for steam locomotives, is one that involves special difficulties, yet is of sufficient importance to warrant supreme efforts on the part of designing engineers. Aside from the problem of how best to connect the moving train with the power house, there are inherent and unavoidable limitations in the constructions of the motors themselves, being principally a matter of available space. Originally, there seemed none too much room between the wheels and between axles and ground for a 15-horse-power motor. The adoption of single reduction gearing was at the expense of raising the flooring from the comfortable level of horse cars with 28-inch wheels to the present stage with 33-inch wheels. 36- and 42-inch wheels are common on steam trains, and with motors beneath the cars, this larger diameter is a practical limit. Though locomotives may readily employ larger diameters, the fixed roadbed does not permit any increase of the space along the axles. Especially is this lack of space felt with gearless motors—that is, when the armatures are mounted directly upon the axles. The expedient is, therefore, adopted of making locomotives with four axles, each fitted with its own motor. The Baltimore and Ohio Railroad tunnel in Baltimore was the first to use such. At full load the total current required per locomotive is 2,700 amperes, the pressure being normally 650 volts, but sometimes increased to 800; as the speed through the tunnel is quite slow, the armatures make only 80 turns per minute. The shafts of the latter are hollow, and through them the axles pass with sufficient clearance to allow for flexible suspension of the motors.

Some radical departures in construction have been adopted in the New York Central locomotives, just now being put into commission. No attempt at flexible suspension has been made, but the armatures are rigidly mounted on the axles; the driving wheels are of relatively small diameter, so as to admit of a higher rate of revolution than in the B. & O. motors. Whereas in the latter there were six poles, N. Y. C. motors have but two, and they present the anomaly of having flat rather than curved polar faces; by this extraordinary device entire freedom for vertical movement of armature is provided, to follow inequalities of track or to permit complete removal from truck. Though in operation somewhat more energy is required to maintain the field magnetism, it is believed

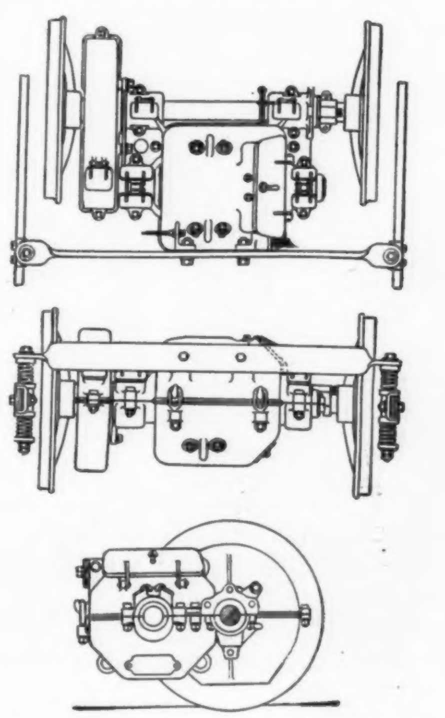


Fig. 36.—Plan, Front, and Side Elevations of Modern Railway Motor in Place on Axle.

the gain in other qualities more than offsets this loss. The trial locomotive successfully withstood its 50,000-mile endurance test under the most rigorous conditions that could be employed. Each of the four motors comprising one locomotive is rated at 550 horsepower, and provision is made for coupling two or more such locomotives together to give the same opportunity for emergencies as is the case with steam engines. The N. Y., N. H. & H. locomotives have also four motors, but they are rated at 200 horse-power only, and afford the interesting and unique spectacle of being designed for single-phase alternating currents. Following the B. & O. design, they are flexibly suspended, but the limitation of space between the drivers has required that the field magnets overhang the drivers and get their bearings near the outer ends of axles. The details of construction of these motors cannot well be considered until explanation is made of the entire subject of alternating currents. Certain it is that the practical working out of the claims of alternating versus direct currents for traction purposes is being done with a thoroughness that interests every engineer, and is prophetic of the entire future of railroading.

The next article will consider the means of controlling motors for railroad purposes.

INJURIOUS PROCESSES IN WORKSHOPS.

A SPECIAL report on dangerous or injurious processes in the coating of metals with lead or lead and tin alloys has just been issued by the British Home Office. This report is based on investigations conducted by Miss A. M. Anderson, Principal Lady Inspector of Factories, and Dr. T. M. Legge, Medical Inspector of Factories, together with conclusions arrived at from a long series of experimental work in workshops and the laboratory by Mr. G. E. Duckering, Inspector of Factories. The work of investigation resolved itself practically into a comparison of the manufacture of terne-plates and the tinning and soldering of iron hollow ware, etc. The contrast between these two trades, in respect of their injurious effect upon the workers, is quite marked from statistics published in this report, and, although not a healthy trade by any means, the manufacture of terne-plates appears to be carried on under conditions which, having regard to all considerations, would appear difficult to improve in any marked degree. Within the scope of the investigation came such processes as the coating of harness furniture with brass or nickel by means of soldering. In such work and in the soldering of large hollow ware done by dipping there must of necessity be some lead in the soldering metal. With the case of tinning merely for the purpose of providing a protective covering to iron or steel, the presence of lead is not so necessary. In the making of terne-plates an alloy of lead and tin is used, but the process is conducted in such a way that no injurious vapors emanate from the bath, or rise from the plates on removal from the bath. This result is attained by allowing no free acid to enter the flux, nor water contained in the flux to come in contact with the molten tinning mixture or alloy, while the plates after tinning have all superfluous metal removed from their surface by mechanical means; and before being exposed to the air the coating is hardened and cleaned.

In the tinning of hollow ware, however, the article is cleaned first of all in dilute hydrochloric acid, is then removed to the flux bath without washing, and then transferred to the tinning bath. The flux is of unknown composition, containing often uncombined hydrochloric acid, and a large excess of water, and on immersion in the tinning bath there is a large evolution of vapor. This vapor, besides being in itself injurious, is produced in so violent a manner that it carries, it is suggested, into the air minute particles of metal from the bath. Further, on removal from the bath the article, from which injurious fumes continue to rise, is wiped of excess of metal by a worker with a pad of tow. In this process the worker is exposed to the vapors arising from the large open bath of metal, and in the wiping process has his face in close proximity to the article just tinned. The employment of tow also seems of a somewhat dangerous character, as small portions of the tow broken off float about in the atmosphere and are inhaled by the workers.

It will thus be seen that in the manufacture of terne-plates the risks are, comparatively speaking, small. Almost the whole process is done under a hood; the plates are handled very little, and not at all until the coating has set hard. The absence of lead poisoning among terne-plate workers is probably due to these points, while the presence of poisoning among workers engaged in tinning hollow ware is due to their inhaling injurious vapors of lead compounds evolved during the several stages of operations. Statistics given in the report go to show that the severity of attacks among workers engaged in tinning hollow ware greatly exceeds that in any of the other lead industries, while female workers suffer more than men, and at a much lower average age. Lead is an accumulative poison, and apparently a few relatively large doses are not so injurious as the continued inhalation of, for instance, lead chloride vapor, as happens in the case of workers in this trade. While lead chloride thus inhaled becomes absorbed into the system through the lungs, and is diffused into the blood, of any taken in by the alimentary tract only a small proportion remains in the system. The report shows that quantities up to 0.294 grain of lead chloride may be inhaled by wipers per diem, and 0.221 grain by workers at an open tinning bath, and 0.037 grain by workers at a bath provided with a hood; while, in addition, the wiper probably inhales 0.326 grain of metallic lead. It is not suggested that these quantities are absorbed into the system, but that they form an estimate of the quantity present in the air from which absorption is possible.

In view of these facts and the number of cases of poisoning reported, certain regulations are suggested, the chief of which are: that no lead shall be used in tinning metal of hollow ware (a suggestion which applies to any tinning process in which chlorides are used); that no female persons be employed in dipping or wiping, and no one at all under the age of sixteen in the process; that the bath be inclosed and provided with exhaust draft; that wiping, etc., be only done with the use of exhaust draft; that health registers be kept, and periodical medical examination be enforced; and that washing accommodation be provided, and washing of the hands be compulsory before leaving the premises or partaking of food. These suggested regulations are not intended to apply to the process of manufacture of terne-plates nor to processes in which no lead is used.

A MOUNTAIN ELECTRIC RAILWAY

TO THE SUMMIT OF THE ALTENBERG.

BY FRANK C. PERKINS.

THE recently constructed electric mountain railway on the German-French frontier has recently been placed in operation between the Schlucht Passage and Münster. This combined adhesion and rack railway passes through one of the most beautiful valleys of the Vosges Mountains, the pure adhesion system being used on the lower grades from Münster for a distance of about four miles on the lower section, and on the upper section for a distance of about a mile to the Schlucht.

The middle section starts about four miles from Münster and rises to the summit of the Altenberg, the rack railway system being employed, as the maximum grade on this portion of the line is about 20 per cent. This rack section is nearly two miles in length, and is provided with grooved running rails of the Vignole profile, while the rack is of the Strub type, similar to that used on the Mount Vesuvius and Jungfrau electric railways. The rack rails are fixed on wrought-iron saddles, and the curves on the rack section have a minimum radius of about 250 feet, and on the adhesion section of about 115 feet. The running rails are 34 feet long, the rack rails are 11 feet long, and the maximum wheel pressure is about 8 tons; that of each driving wheel being about 4 tons.

The accompanying illustrations show the double overhead trolleys and the bow collectors on the rack as well as the adhesion sections.

The power station of the Münster-Schlucht electric railway on the German-French frontier is equipped with two horizontal cross-compound reciprocating engines driving two three-phase alternating current generators of 200 kilowatts each. These engines are supplied with steam from two boilers, each having a heating surface of about 880 square feet and working under a pressure of 170 pounds per square inch.

The boiler plant is provided with two superheaters and one economizer of the Green type, as well as with feeding pumps within the boiler house and condensing pumps outside of the power plant.

The current generated by the alternators in this power station has a frequency of fifty periods per second and a pressure of 7,000 volts. It is used for light and power service in the country surrounding the city of Münster as well as for operating the electric mountain railway.

The railway station at Münster is 1,250 feet above the sea level and about a half a mile below the Schlucht station, which is nearly 3,800 feet above the sea level.

The current is conducted from the power plant at Münster over a power-transmission line on wooden poles at a pressure of 7,000 volts to a single converter substation. At this substation there are two motor-generator sets having a capacity of 200 kilowatts. The motors are of the three-phase type and directly coupled with flexible couplings to the dynamos, which supply current to the trolley line at a pressure of 750 volts. There is a storage battery regulating plant of 390 cells arranged in parallel with the railway feeders and the direct-current generators at the converter station, this storage battery installation having a capacity of about 300 ampere hours.

The trains on the Münster-Schlucht electric railway to the summit of the Altenberg consist of nine trains per day in summer on week days and about double this number on holidays and Sundays, while in winter the number of trains is reduced about one-half this number, and the line is only operated during the winter season as far as Ampfersbach.

There are two trains on the line in continuous service, one traveling up the mountain and the other down, each consisting of a trailer hauled by a four-axle motor car weighing about 25 tons. The total weight of the train including passengers is about 35 tons. The motor car is provided with four driving axles, two of which are equipped with adhesion motors and the other two with rack motors, constructed by the Alioth Electric Company, of Basle, Switzerland. The two adhesion motors have a capacity of 85 horsepower normal output and a maximum output of 100 horse-power, these motors being used on the upper and lower adhesion sections alone. The two rack motors are of the same capacity, and on the heavy grades four motors are used, having a total output of 350 horse-power. The rack motors may be thrown out of gear when desired, having double transmission, while the adhesion motors have simple transmission.

TWO VIEWS SHOWING RACK.

THE MOUNTAIN ELECTRIC RAILWAY TO THE SUMMIT OF THE ALTENBERG.

THE EFFECT OF VANADIUM IN STEEL.

By E. T. CLARAGE.*

VANADIUM is not a new discovery. Its existence was known as far back as a century ago under the name of "erythronium." It was not, however, until thirty years later that it was again discovered and given its present name.

About forty years ago Sir Henry Roscoe is credited with having obtained the pure metal and learning something of its properties, particularly its ability to combine with oxygen.

Until recently it has been classed as one of the rare metals, although it has been used experimentally in steel since about 1902 and was also used in small quantities by the English wire drawers some eighteen years ago. It was found in such small percentages in combination with other metals that the cost of reducing it made the price prohibitive. Even up to a year ago the price has been ten dollars a pound or over. A large deposit has recently been discovered in South America as a sulphide, and although the present cost is a little more than half the price of silver, it may be possible that as the demand increases the cost may be still further reduced.

For many years it has been an axiom that phosphorus and sulphur were the two deadly enemies of steel. The wonderful science of modern chemistry is only a little over a hundred years old and its application to the art of steelmaking dates back not much more than half that period.

The most advanced metallurgists have just begun to appreciate that there are other elements which are much more harmful, and which have rarely been computed. The two exceedingly elusive gases, oxygen and nitrogen, are usually present in small quantities in all forms of steel and the presence of either one is exceedingly harmful.

In the Bessemer process the carbon in the iron is burned out by forcing an immense quantity of air through the molten mass, the oxygen combining with the carbon, and the other constituent of air, or nitrogen, nearly all passing off without producing any kind of an action.

Unquestionably a certain amount of the nitrogen gas remains in the steel. In fact, an analysis will show the largest amount of this gas in Bessemer steel, a smaller amount in open-hearth, and a very much smaller amount in crucible steel. This is probably the reason why a crucible steel is much superior to the best open-hearth, even though the carbon, manganese, phosphorus, sulphur, and silicon may be the same in each.

The value of the Bessemer process to the world is almost beyond calculation, yet in the light of recent discoveries and developments it will eventually be considered as only a step in the process of evolution, and unless modified or greatly improved it will certainly have to give way to the open-hearth method.

Vanadium, even in very small doses, has the property of combining with both oxygen and nitrogen at high temperatures. In fact it acts as a purge or cleanser in driving them out of the metal. So powerful is its influence on nitrogen that one-half of one per cent is sufficient to eliminate nitrogen entirely. In introducing this amount, about one-half of the vanadium will be found in the steel and the presence of even one-tenth of one per cent in the finished steel is a guarantee that the nitrogen has been separated from the steel and driven out.

The effect on oxygen is the same, but this is not nearly so important, as we have other much less expensive materials which take care of oxygen under ordinary circumstances.

Manganese is a deoxidizer and metallic aluminium is still more effective. Theoretically, 229 parts by weight of manganese will combine with 100 parts of oxygen (Mn_2O_3), while 113 parts of aluminium will combine with the same amount (Al_2O_3). The peculiar value of aluminium is in the fact that when introduced into the melted steel in just the right proportions it passes into the slag or flux as oxide of aluminium, combining with silicon to return it to its origi-

* The Iron Trade Review.

nal state of finely divided clay, and leaves no trace of itself or oxygen in the steel.

The analysis of nitrogen in steel is theoretically very simple, yet it is a very difficult analysis to make and quite beyond the ordinary chemist.

In addition to its chemical action on nitrogen and oxygen, vanadium also produces another result which has been called a mechanical action, although it is more properly another chemical combination.

Under the microscope a piece of hardened steel which has been surface polished and etched will show the hardening carbon in the form which has been called martensite and which in a piece of pure carbon steel will be found in irregular splotches. Prof. Arnold is of the opinion that vanadium combines with carbon to form a double carbide of iron and vanadium which may account for a part of its physical effect.

The microscope reveals beyond question that the presence of this alloy causes a different arrangement of hardening carbon, it being more uniformly knit together throughout the mass.

The physical characteristics of vanadium steel are higher tensile strength (breaking point), higher elastic limit (stretching point), and resistance to fracture from successive shocks.

F. W. Harbord in his last edition of "Metallurgy of Steel" says a nearly pure iron and carbon steel containing about 1.10 per cent carbon has an elastic limit of about 60,000 pounds and a tensile strength of about 120,000 pounds per square inch. He states that as small an amount as 0.14 per cent vanadium has raised the elastic limit to 86,000 pounds and the tensile strength to 134,000 pounds. He reports the effect of 0.3 per cent in the same steel as giving 152,000 and 0.6 per cent 190,000 pounds tensile strength, the last having an elastic limit of nearly 130,000 pounds per square inch.

Nearly all recent experiments have been made with open-hearth steel in which phosphorus and sulphur ran as high as 0.03 or 0.035, which is far above the limit even in ordinary low-priced tool steel.

It must not be supposed for an instant that vanadium is a miraculous substance which will neutralize the effect of phosphorus and sulphur, and the steel maker or consumer who is led astray by any such idea still has his troubles ahead of him. It is a fundamental fact that results obtained with any combination having iron as its base will be in direct proportion to the amount of phosphorus and sulphur present.

We now come to the most interesting feature of vanadium from the standpoint of the tool steel maker.

A hundred and fifty years ago, when the steel maker knew nothing about chemistry, he found simply by experiment that certain Swedish irons make the best steel. This became tradition, and to this day we are still guided by it. These Swedish ores are found in a remarkable state of purity and are melted and refined entirely by the use of charcoal as a fuel in order to prevent the iron from taking up any sulphur.

It is possible, starting with the purest American irons, to eliminate phosphorus and sulphur to a great extent; in fact American iron can be produced as low in these impurities as the best imported iron. Nevertheless there is a distinct difference in the quality of tool steel made from them. The old steel maker will tell you that the Swedish irons have the "body," and it is a fact that only a few pounds used with the American iron will have a noticeable "toning up" influence.

Prof. John W. Langley tells me that he made an exhaustive study of this subject some fifteen years ago and that he found that the best Swedish irons were practically free from nitrogen, which was always present in the American irons. As this is the only difference he could find between the two, he was obliged to think that nitrogen was the element which was responsible for the different results.

The German technical paper, Stahl und Eisen, recently gave the results of some determinations on the influence of nitrogen in iron made by H. Braun, who discovered alterations in the physical properties of the metal. An iron wire of the composition of 0.08 per cent carbon and 0.027 per cent nitrogen was nitrated with dry ammonia gas. After nitrating, the percentage of nitrogen was found to be 0.267 per cent.

The original wire stood fifteen or sixteen deflections. The nitrated wire was unable to stand more than two or three.

Curiously enough, we are only beginning at this late date to discover the reason for the Swedish iron being so much more free from this element. Prof. Howe, in his "Metallurgy of Steel," speaks of vanadium and says that Sefstrom discovered it in the bar iron and refinery slags from the Taberg (Swedish) ores. He states further that Riley has found 0.686 per cent of it in the cast iron.

Mr. J. Kent Smith, who is at present connected with the production of vanadium in America, is quoted as saying that his first experience with vanadium was in a piece of Swedish iron which had done remarkably good work. He further states that this iron contained a considerable amount of vanadium and adds that most Swedish irons contain some.

In the light of present developments it is evident that the finding of vanadium in the slag was evidence that it had performed its remarkable function in carrying off nitrogen and oxygen, and its presence in the refined irons was a guarantee that there was no more of these elements present.

There is certainly a great field for this alloy in

HIGH-TENSION POWER TRANSMISSION OF THE RAILWAY.

open-hearth and Bessemer steel, where its cleansing effect is most needed, but if tool steel is made from these pure high-grade Swedish irons the purging action has already taken place and there is little or nothing to be gained along the same lines by adding more.

It is a well-known fact that a low-grade tool steel deteriorates much more rapidly under successive hardenings than a high-grade product. The process of hardening itself is a tremendous shock to the material as a result of the sudden contraction. One of the most important results from the use of vanadium is that the resistance to dynamic strains or shocks is greatly increased. Therefore a tool steel made from these Swedish irons which contain even traces of vanadium will outlast the ordinary low-priced tool steel many times.

I do not mean to say that vanadium will not be used in tool steel. In fact, it has other properties which may make it eventually a substitute for tungsten in the manufacture of high-speed steel, when the cost is such that it can be used in larger proportions.

Man has accomplished wonders in combining the elements synthetically in imitation of nature, but there remains much to be done.

The diamond is simply a form of pure carbon, but its production in the laboratory has not yet been accomplished in a commercial way.

We are obliged to admit that there are processes in Nature's laboratory that man cannot imitate or even faintly comprehend.

Nature effected a combination of vanadium and iron in the Swedish ores millions of years ago, and at the same time was kind enough to furnish them almost free from phosphorus and sulphur.

The tool steel maker who makes use of the best product of Nature's laboratory can be reasonably sure of the quality of his product.

THE STRENGTH OF STRUCTURAL TIMBER.

LOBLOLLY, longleaf, and Norway pines and tamarack are among the principal structural timbers of the eastern United States, and Douglas fir and western hemlock of the western. Recent tests by the Forest Service show longleaf pine to be the strongest and stiffest of all the timbers named, with Douglas fir a close second; while western hemlock, loblolly pine, tamarack, and Norway pine follow in the order given. Fortunately, Douglas fir and western hemlock, of which there are comparatively large supplies, have high structural merit, as has also loblolly pine, the chief tree upon which the southern lumber companies are depending for future crops.

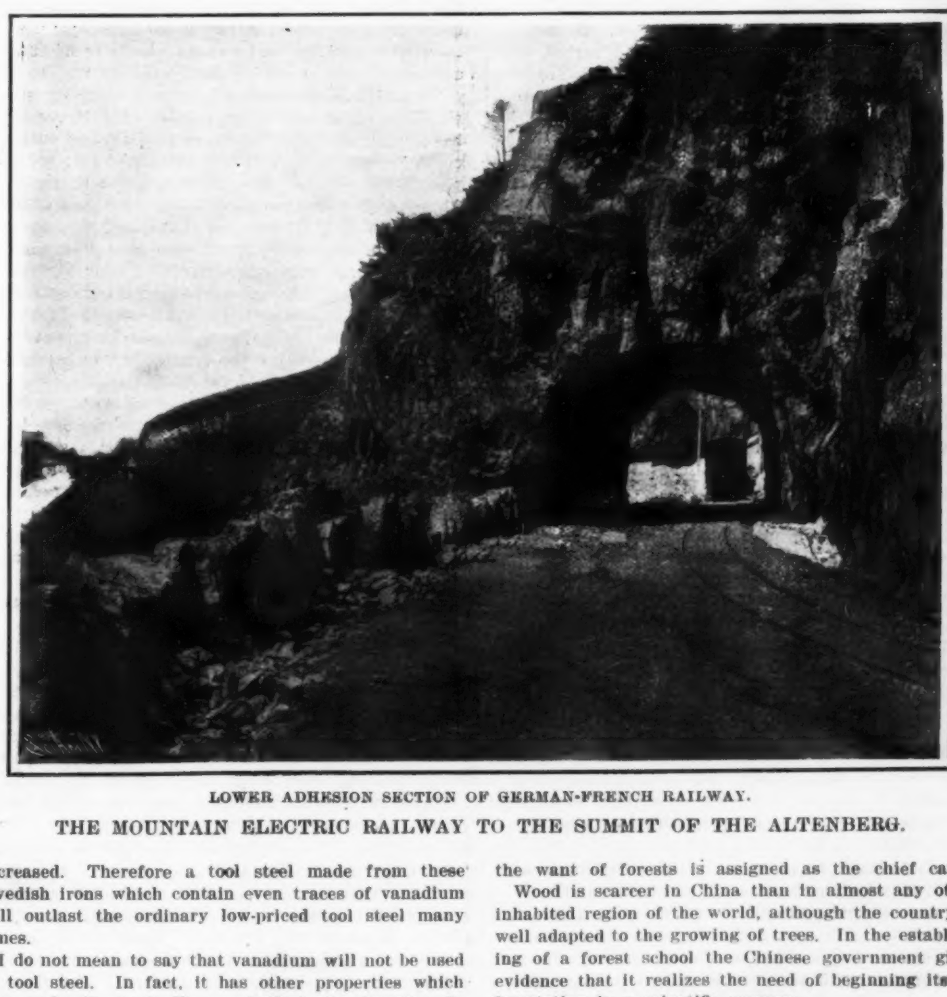
Much of the information hitherto available concerning the strength of timber has been secured from tests of small pieces without defects. This can not safely be assumed to hold good for large-sized timbers as found on the market, since these commonly contain such defects as checks, knots, cross grain, etc. The location of the defects varies the extent to which they lessen its strength; and the proportion of heart and sap wood, and the state of seasoning, must also be considered.

A CHINESE SCHOOL OF FORESTRY.

THE almost world-wide movement to protect and establish forests has reached China, and the first Chinese school of forestry will shortly be opened in Mukden, according to a recent report by Consul-General James W. Ragsdale, at Tientsin.

The Chinese Empire is sometimes pointed out as the worst example, among modern nations, of forest destruction. The floods which are periodically poured down from the denuded mountains are destructive beyond comparison with those of any other country, and the want of forests is assigned as the chief cause.

Wood is scarcer in China than in almost any other inhabited region of the world, although the country is well adapted to the growing of trees. In the establishing of a forest school the Chinese government gives evidence that it realizes the need of beginning its reforestation in a scientific manner.



LOWER ADHESION SECTION OF GERMAN-FRENCH RAILWAY.

THE MOUNTAIN ELECTRIC RAILWAY TO THE SUMMIT OF THE ALTENBERG.

DRY ROT IN TIMBER.

ITS CAUSE AND PREVENTION.

SOME progress has been made in recent years in the application of scientific knowledge to the prevention of the decay of building materials, but the destruction of timber attacked by dry rot still continues to be a frequent source of trouble to builders and householders. It has long been known that dry rot is caused by the growth of a fungus known as *Merulius lachrymans* upon the timber, that the fungus is propagated by spores, and that (though oddly called "dry" rot) it can live only in the presence of moisture; but further information is required to enable infected timber to be detected before it has suffered any damage. One feature of good timber is that it emits a sonorous sound when struck, but if the timber is in such a bad condition that, when struck, it emits a dull sound, that timber is already unfit for use. The test which consists in boring into the timber with a gimlet or auger is also useless for detecting incipient dry rot. It would be interesting, in the case of a decayed floor, to know how the first spore or seed from which the fungus was developed was brought in contact with a floor board which was in perfect condition when the floor was constructed.

Much was written during the last century by Bowden, Britton, and others concerning dry rot, and many remedies and preservatives were recommended, but very little advance has been made within the last forty years in our knowledge of the subject. Many architects and builders have no doubt had to deal with interesting cases of dry rot, and we should welcome any correspondence which is likely to throw further light upon the nature of the disease and the methods by which it may be successfully combated.

The fungus which is responsible for the appearance of dry rot in timber emanates from a spore which has been deposited upon the timber, but only when the timber is moist and surrounded by stagnant air can the spore develop into a flourishing fungus. The finest [illegible] grow upon timber exposed to a warm, damp atmosphere, [illegible]tion free from drafts.

The appearance [illegible] the fungus varies with the conditions under which it grows, but it usually assumes the form of a soft web of white, yellow, or brown color [illegible]ed over the surface of the timber. Its growth is accompanied by the emission of a musty odor. When the growth is allowed to proceed unchecked, the timber is gradually converted into a mass which can easily be crumbled to powder in the hands, and the web-like fungus is seen in the interior of the wood as well as on the surface. On balk timber the fungi sometimes assume the form of red spots. During the process of the decomposition of the wood, carbon dioxide, water, and other more complex gases are produced. When a spore has commenced to grow upon the timber the fungus which is developed from it speedily reaches a sufficiently mature state to throw off from itself numerous spores which in turn develop into fungi, if the timber continues in condition suitable for fungus growth.

The fungus cannot live without water, and dry timber exposed in a dry atmosphere cannot, therefore, be attacked by dry rot. The spread of dry rot in timber may be due to some defect in the timber itself, or to the exposure of good timber to conditions favorable to the growth of the dry rot fungus. If the timber has not been properly seasoned, and contains, therefore, a considerable quantity of sap, the speedy appearance of dry rot may be expected. Unseasoned timber stacked in such a way that fresh air cannot play freely around it is very liable to be attacked. Timber which has been varnished or painted before it has been sufficiently seasoned is also prone to attack, because it is kept always in a moist condition, owing to the water of the sap being imprisoned by the waterproof coat of paint or varnish.

The most common cause of the development of dry rot in houses is the construction of a kitchen floor over damp earth, or over a moist concrete foundation, and the covering of the upper surface of the floor with linoleum or other material which prevents access of fresh air to the surface of the timber. Timber so treated is exposed to all the most favorable conditions for the rapid growth of the fungus, viz.: (1) Presence of moisture; (2) warmth; and (3) exposure in stagnant air. It is worthy of note that although moisture is essential to the fungus growth, yet timber kept under water appears to be immune from dry rot.

It should be remembered that most of the conditions which favor the growth of the dry rot fungus are inimical to human life, and the appearance of the fungus upon the walls or floor of a dwelling room should, therefore, be accepted as evidence that the atmosphere in the neighborhood of the fungus is stagnant and damp, and liable to injuriously affect persons exposed to its influence. Fresh air and sunlight, which are so beneficial to animal life, will destroy dry rot fungi in a few hours.

To insure that timber used in building construction shall remain free from dry rot, only properly seasoned timber should be used, and, so far as is possible, it should be protected from contact with damp, stagnant air. Care should also be taken that every piece of timber used in the building is sound, and free from visible sign of infection.

The most effective inexpensive method of protecting timber from the dry rot fungus and other destructive organisms is to subject it to the creosoting process so largely used for preserving railway sleepers. The timber is first placed in a vacuum to remove most of the moisture and air, and is then treated in the same chamber with hot creosote under high pressure. This treatment insures far better penetration of the creosote into the interior of the timber than can be obtained by merely painting the wood with creosote. The use of creosoted timber is, however, impossible in most buildings, owing to the odor it emits, and to the effect of the creosote upon the appearance of the wood.

For both prevention and cure of dry rot exposure of the timber to fresh air and sunlight is the best treatment, but where this is impossible the timber may be impregnated with a suitable metallic salt or with an antiseptic oil. Some of the salts, however, which have been suggested for destroying the fungus are so poisonous in themselves that in many cases it would not be safe to use them. Treatment of the timber with a solution of mercuric chloride, as recommended by Kyan, is expensive and would be dangerous for use in dwellings. Arsenic salts are also dangerous. A saturated solution of copper sulphate, which is frequently recommended, is cheaper, and not so objectionable as mercuric chloride, but copper sulphate is, nevertheless, a poisonous salt.

Others have proposed the use of mineral acids, such as sulphuric acid and hydrochloric acid, for destroying the fungus, but these are liable to injure the timber. Acid solutions of metallic salts, such as acid chloride of zinc, are also objectionable. Petroleum has also been recommended, but this increases the inflammability of the wood, and causes it to emit a disagreeable odor of petroleum for a very long period.

Many patented compositions, sold under fancy names, have been used with more or less success. The most effective usually owe their efficiency to the presence of one or more distillates from coal tar. The use of an alcoholic solution of salicylic acid has been recommended. This would have the advantage of leaving the timber odorless, and would probably be as effective as creosote, but would be much more costly.

No useful purpose would be served by giving a complete list of the very large number of mixtures which have been advocated at different times as infallible cures for dry rot. Some of them are absurdly complex, such as the following: A solution containing 3.3 per cent of manganous chloride, 2 per cent of orthophosphoric acid, 1.2 per cent of magnesium chloride, 1 per cent of boric acid, and 2.5 per cent of ammonium chloride. Any builder let loose in a drug store could no doubt succeed in compounding an equally formidable mixture for the unfortunate fungus, but such frenzied efforts are quite unnecessary. There is no difficulty in destroying the fungus, but to prevent its renewed growth in the case of the under side of a kitchen floor constructed over damp earth or damp concrete, and where proper ventilation cannot be obtained, is a difficult matter. If the ground beneath the floor consists of earth, and the fungus can be seen growing upon it in patches, some good may be done by removing as much of the earth as is practicable, and putting in its place dry sand free from vegetable mold; but we doubt whether any treatment which does not include exposure of at least one side of the floor boards to currents of fresh air will prove wholly satisfactory.—The Builder.

FISH SCRAP.

UTILIZATION of Fish Scales.—A process has been discovered whereby fish scales can be utilized in the manufacture of ornamental articles, artificial flowers, inlaid work, and the like goods. Painting by means of fish scales, however, when the scales are held together by any suitable adhesive, has been superseded by the more easily applied and readily colored mica scrap. Edward and Julius Huebner, of Newark, have patented the following process:

The fish scales are cleansed in a suitable manner until they present a transparent and horny appearance. Large scales from fresh fish insure the best results; old scales cannot be used, as they have lost their elasticity and transparency. In the Huebner process, fresh scales are first treated for twenty-four hours in pure salt water, to loosen and partly dissolve the upper strata. They are then washed in distilled or pure rain water, which is renewed every two or three hours. This is repeated five or six times. The scales are then separately and carefully rubbed off with a linen cloth, and gently pressed in a press to remove the moisture. Finally, they are immersed for an hour in alcohol, and again, as before, rubbed off and pressed until they are dry. They now have an appearance resembling that of mother of pearl, and are very elastic and durable. They can be used as they are, or colored as desired.

Fish scales are used in the preparation of pearl essence or fish scale essence. The white fish we know as the bleak (*Leuciscus alburnus*) common in many waters, is washed carefully in water, to cleanse it from any adhering dirt, and then carefully scaled, pains being taken to remove only the scales and not to accompany them with blood or particles of skin. The scales are carefully collected and temporarily deposited in a vessel filled with water until a sufficient quantity has accumulated to warrant further treatment. The scales of nearly 40,000 bleak fish are required to make a kilogramme (2.204 pounds) of pearl essence, a quantity which of course suffices for the production of many thousands of artificial pearls.

It is best to keep the vessel containing the scales in an airy attic, for they soon begin to decompose and give off an exceedingly disagreeable odor. To prevent this, we can proceed as follows: In place of pouring water on the scales, we use a solution of salicylic acid, prepared by dissolving in 1,000 parts by weight of water, 3 parts of salicylic acid. The salicylic acid is tied up in a linen bag and suspended in the water, so that it will gradually dissolve. By employing this simple precaution, the collecting vessel may be allowed to remain in a room without proving in the least offensive. When a sufficient quantity of scales has been collected, the fluid standing over them is poured off and a portion of the scales transferred to a large porcelain mortar, in which they are rubbed for a long time with a smooth pestle. As a result of the rubbing, the particles that cause the silvery appearance are removed from the scales. After prolonged rubbing, water is poured onto the charge in the mortar, which is thoroughly washed with it. Finally, the contents of the mortar are poured onto a closely woven linen cloth, stretched over a tub. The finely-divided scale-coloring substance, suspended in the water, passes with the water through the cloth; meanwhile the scales undergo another rubbing and washing with water, by which means we obtain more coloring substance. The latter being now all collected in the tub, the fluid is thoroughly stirred, allowed to stand for a time and then drawn off into glass bottles, in which it remains until the coloring substance has wholly settled on the bottom. The coarser portion of the coloring substance left in the tub is again stirred into water and washed out.

The water standing over the coloring substance is carefully poured off and the substance finally collected in one bottle. In a moist condition it is of silvery white color, very brilliant; if we dry it we obtain a delicate silver gray powder. Under salicylic acid solution, this fish scale essence can be preserved for a long time without undergoing any change.

The filling mass for the beads is produced in the following manner. Completely colorless gelatine is allowed to soften in an aqueous solution of salicylic acid. The fluid is then poured off and the gelatine melted, by careful application of heat, in a porcelain dish, until a clear fluid is obtained. To the latter we add some of the fish scale essence, mixing it intimately with the gelatine. As to the relative proportions of gelatine and fish scale essence, no definite figures are available, but as a standing rule, no more of the latter should be employed than is absolutely necessary, as it is an expensive substance; only so much of the essence is taken, therefore, as will suffice to completely coat glass beads when it is introduced into them.

The introduction of the mixture, melted in a water bath, is effected by means of a glass tube, drawn to a point, with the aid of which a drop is allowed to pass into the hollow inside of the glass bead, so that its inner surface will be completely covered.

To prevent the coating's becoming detached from the glass sides, and at the same time to give the beads greater weight, the interior is poured full of molten wax, or a mixture of wax and paraffine; in the case of pear-shaped pearls, having but one opening, they are filled with wax and the aperture closed with a drop of melted pearl essence.

J. Loreau, at his factory in Kernevel, near Lorient, uses fish in the manufacture of sardines in oil. The process results in the production of considerable offal,

consisting of heads, cartilage, intestines, bloody brine, etc. This offal is collected, after draining, heated in a kettle, and pressed. The resulting cake, when dried and ground, produces a fertilizer.

Treated with sulphuric acid, this fish guano is said to be especially adapted for beets.

A substitute for isinglass, as well as for gelatine and glue, from fish and fish scrap, is made by C. A. Sahlström, Stockholm, according to a patent granted to him, by treating the same with chloride of lime, permanganate of potash and nitrous and sulphurous acid vapors.

In the process the fish or fish parts are first well steeped in fresh water and then allowed to lie from three to four hours in a solution of about 0.085 part of chloride of lime to 25 to 30 parts of water. After it has been rinsed off, it is treated for about thirty to forty minutes in a solution of about 25 to 30 parts of water to 0.005 part of permanganate of potash, and afterward exposed to the action of the fumes of the nitrous gases produced by heating 0.3 to 0.4 part of nitric acid to every 40 parts of raw material.

We can also allow this gas to be absorbed by water, as is done in the manufacture of sugar, or, in place of the nitrous acid, we can use sulphurous acid gas, made by burning about 2 parts of sulphur to each 40 parts of raw material. Thus treated, it is finally rinsed off and the parts intended for the isinglass substitute, after the outer skin has been removed, are dried at low heat, and pressed. The portions intended for gelatine or glue, however, are exposed for ten to twelve hours to a temperature of 40 deg. to 50 deg. C., by which they are in great part dissolved; this mass is then forced through a screen or a sieve, allowed to stand for a few hours, and finally dried in the manner practised in the manufacture of glue or gelatine.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the German of Dr. Theodor Koller in Verwerthung von Abfallstoffen aller Art.

THE MOST IMPORTANT SWEET SUBSTANCES.

THEIR MANIFOLD USE AND OCCURRENCE.

IN almost all branches of the manufacture of victuals and palatable foods, sweet substances play a prominent part. In the brewery, in the bakery, and in fruit preserving, in every household they are indispensable, and when we sit down to dinner we are able to trace them in the most varied forms on the menu card. But they are not only called to tickle the spoiled palate of the gourmand, on the contrary, they represent, in the shape of natural sugars (carbohydrates) one of the foods most widely spread among all the nations of the world.

Just as manifold as their use, is the occurrence of sweet substances in modifications which are partly closely related to and partly entirely different from each other.

Fundamentally we must, therefore, distinguish between natural and artificial sweet substances, between sugars (carbohydrates) and substitutes for sugar. As most important sugars saccharose, dextrose, levulose, lactose, galactose, maltose, glycyrrhizine, and glycerine, may here be discussed; of the substitutes for sugar which, according to origin and composition, have almost nothing in common, saccharine may be placed at the end.

All natural sugars consist of combinations of carbon with the elements of water, hydrogen and oxygen, expressed by the general term "carbohydrate."

Perhaps the best known means of sweetening and one with which we are rarely saving, is cane, or beet-sugar, saccharose. It represents, in shape of floury snow-white powder, or in hard crystals as cube and loaf sugar, an indispensable requisite of every kitchen. Saccharose is a natural product of many kinds of plants and is obtained on a large scale from sugar-cane and sugar-beet. In the most recent decades there developed, especially in Germany, a flourishing beet-sugar industry, so that, at the present time, over half the total annual production of about 12 milliard kilogrammes is produced from the sugar-beet. However, it is to be expected that, in time within sight, the cane-sugar industry of Cuba, under American government, will develop better than under the former Spanish régime, so that, perhaps, a shifting in favor of cane-sugar may again take place.

The wide and general use of saccharose is due to its great crystallizability, its great solubility in water, both hot and cold, and, especially, to its pure sweet taste. By yeast, saccharose cannot, without previous splitting into more simply composed sugars, be made to ferment. For this reason, it is not directly adapted to the production of alcohol, and is, therefore, used mainly for the refinement of victuals and aliments, for the preparation of foods, preservation of fruit, in pastries and in candy manufacture. How great its importance as a food of the people is, may be seen from the fact that in all civilized countries the consumption of saccharose in 1900 surpassed 12 kilogrammes per head of the population, and in England even amounted to as much as 30 kilogrammes.

Closely related to saccharose are dextrose and levulose, since both of these are formed side by side by a decomposition of beet (cane) sugar under the influence of, for example, dilute sulphuric acid. The mixture of both is called invert sugar; it is that sweet substance which gives to honey its pleasant, mild-sweet, fruit-like taste. Dextrose, in particular, is found especially in grape-juice, the reason why it is also generally called grape-sugar, and it is widely used in the production of artificial wines and unfortunately for the improvement of the poorer brands. A generally known and popular form of the use of dextrose is syrup, that delicious substitute for natural honey in household and kitchen; also the confectioner and jelly manufacturer well know its value and how to apply its good qualities. In factories dextrose is produced by the treatment of starch with highly diluted sulphuric acid (starch-sugar). Levulose, also called honey-sugar, is in nature almost always found together with dextrose in most fruits. It is the real sweetening principle of natural honey in which it exceeds the dextrose. For a few years past honey-sugar has been made in yellowish transparent lumps by the firm of Merck in a pure condition. This product is easily deliquescent and like dextrose, easily soluble in water. The production of artificial honey has, naturally, been greatly facilitated and refined by this so that to-day the housewife cannot be careful enough when purchasing even the finest honey. During fermentation under the influence of yeast, alcohol is formed out of levulose; in this particular also levulose has exactly the same behavior as dextrose. Only by means of an optical method of investigation is it possible to recognize these sugars according to their character; under this method they show a directly opposite behavior.

A sugar of extraordinarily high physiological significance is lactose or milk-sugar. Almost every man owes a great deal of his thriving in tender infant-age to it, since lactose is an important constituent of mother-milk which is indisputably necessary to growing man as the most natural and best source of life. Lactose occurs in the milk of all mammals and in milky secretions of some kinds of plants. It is obtained on a large scale from the milk of cows, and, in pure condition, it forms hard crystals which grate between the teeth and which easily dissolve in 6 parts of cold or in 2 parts of hot water. Such a solution tastes peculiarly dull-sweet. In the main, lactose is used as addition to cows' milk if its nutritious value is to be increased or if the alcoholic beverage "koumyss" is to be produced from it. By fermentation, lactose cannot immediately pass over into alcohol, but forms lactic acid. This process may be observed if fresh sweet milk is allowed to stand for a few days at ordinary temperature. The lactose is then, for the greater part, transformed into lactic acid which gives to the so produced thick liquid those well-known refreshing thirst-quenching qualities which make it so popular in extreme heat.

However, if diluted acids are allowed to act upon fresh sweet milk, then lactose is, as above in the case of saccharose, "inverted" and a more simple sugar, milk-invert sugar or galactose, is formed. Galactose, now, is fermentable in the ordinary sense so that, by means of simple operations delicious alcoholic beverages may be obtained from sweet milk, the best known of which are, perhaps, "koumyss" and "kefir" so widely spread in Russia. The taste of galactose itself is, in aqueous solution, peculiarly honey-like and floury-sweet.

A sugar which finds but little direct application, but which plays a prominent part in beer brewing and the manufacture of alcohol, is maltose or malt-sugar. In nature maltose hardly occurs, but it easily forms if starch-flour and starch-containing soil-products such as grain, rice, Indian corn and potatoes, are at a certain temperature, mixed with diastase, an enzyme contained in germinating barley. Maltose is a main constituent of beer-wort, has a pleasant, slightly sweet taste which is similar to that of dextrose, and the quality to be easily fermentable into alcohol.

Glycyrrhizine-ammonia or licorice-sugar is the real sweet principle of licorice and of monesia-bark which are obtained especially in the South European peninsulas, Italy, Spain, and in Southern Russia. As licorice, this sugar represents a dainty popular with children. Pure glycyrrhizine-ammonia crystallizes in transparent leaflets which are easily soluble in water and which in solution, have a taste which is at first pleasant, but later becomes scraping-sweet. Yeasts do not seem to have a fermenting effect. The concentrated aqueous extract of licorice which has been molded into sticks is that somewhat plastic deep-brown mass which is commonly known by the name of licorice and is used for a dainty or for food purposes. In home medicine its aqueous solution is successfully applied as an irritation-removing remedy in the case of cough.

At the border-line, so to speak, between carbohydrates and substitutes for sugar stands glycerine. In nature it does not occur in ready formation; however, it is an important constituent of almost all vegetable and animal fats and oils, for example of tallow, lard, butter, linseed oil, and olive oil. All these substances are combinations of glycerine with organic fat or oleic acids. They also consist only of carbon, hydrogen, and oxygen, but in materially different proportions so that, with reference to them, the term carbohydrates is no longer correct. In the waste-lyes of the manufacture of soaps and stearine-candles which is founded mainly on the decomposition of fats and oils, glycerine is found in great quantities and may be obtained from them by the use of simple means. Pure glycerine is a limpid, sweet-tasting liquid which may be mixed with water in any proportion.

The uses of glycerine are manifold. Since in the fermentation of sugars there forms incidentally also glycerine, we consume it almost always in normal wine or beer. Furthermore, it serves in a large measure for the preservation of aliments which are to remain moist, for fruit, mustard, etc. With the same purpose it is used for anatomical purposes. Its use as a cosmetic is, perhaps known best of all. On the dresser of every lady it may be found in the most varied forms. While, furthermore, mixtures of glycerine and water do not easily become solid and evaporate, they serve for filling gas-meters which may without fear be exposed to heat or cold. Finally it may be mentioned that glycerine is used in enormous quantities annually for the production of dynamite.

So we meet with glycerine many times in daily life. At a well-filled table we derive pleasure from it. It digs the coal in the mine for us, and defends or destroys in the hand of the soldier our life and our property.

That characteristic quality which causes saccharose to be used annually in such enormous quantities in foods, consists apparently only in the fact that it tastes pleasantly sweet at once. Now the sugar substitutes or artificial sweet substances possess this quality in a much higher degree.

The best known one of these substitutes, saccharine, is, to be sure, not easily soluble in water, but is approximately 550 times as sweet as saccharose. Its production is protected for the German firm, Fahlberg & List, of Sallke o./ Elbe, by numerous patents. It forms a white fine crystalline powder of a weak bitter-almondlike odor, which becomes clearly noticeable by heating to about 200 deg. C. Saccharine sublimes above 200 deg. C. undecomposed, while with all other natural sugars there takes place, not sublimation, but decomposition with the formation of a brown-coloring (caramel formation). A quality which it has in common with saccharose is this that its crystals, crushed in the dark, are clearly luminous. Its composition is radically different from that of the carbo-hydrates, for it contains still a fourth element, sulphur. It is produced by a difficult and expensive process from toluol, a constituent of coal-tar. Since 1 kilogramme of saccharine costs about \$7, its price would be small in consideration of the sweet value contained therein, for the equivalent 550 kilogrammes of good sugar would represent a value of about \$70. In the first time of its appearance on the market the supposition was, therefore, that here had arisen a dangerous enemy to the sugar industry. However, this fear has in time proven to be entirely groundless. For saccharine has only in certain cases advantages over saccharose. Thus it is of value for persons suffering from diabetes as a welcome harmless substitute for sugar. Unfortunately it is often used also in the production of champagne and of artificial wines because the beverage does not become sticky from it and does not disclose the fact that sugar has been added. For jellies, compots, etc., it is frequently preferred because it does not crystallize out like sugar.

But although saccharine has been known since 1885 and has been sufficiently advertised, saccharose calmly proceeded on its path outlined above and its con-

sumption has increased regularly. The reasons for this are to be sought in the fact that saccharose, as differing from saccharine, belongs to the group of carbohydrates which are, in general, indispensable to the human body. Saccharine, however, passes through the organism without change and is again secreted as such. For this reason, perhaps, it is often facetiously called "round-trip sugar." Although it is not injurious if taken in small quantities, it is, however, in the most favorable case nothing but a harmless spice.

Fats, albumen, and carbohydrates, however, are not only those organic compounds which nature mainly forms, but at the same time, those substances which are absolutely necessary for the support of our systems.—Dr. L. Haupt, in Pure Products.

SIR WILLIAM CROOKES, F. R. S.

THE APOSTLE OF RADIANT MATTER.

SIR WILLIAM CROOKES has the rare privilege of looking back upon a scientific activity extending already over more than fifty-five years. By numerous papers and by several volumes, the results of his experimental researches in different departments of physics and chemistry have been spread all over the world. Though born in 1832, even his advanced age has not diminished his scientific productiveness.

All Sir William Crookes's researches, with the exception of the first, were made in his private laboratory in Kensington Park Gardens. Although the motion of the walls of this laboratory, as seen under the high magnifying power of the horizontal pendulum, gave rise, at first sight, to doubts as to the solidity of its construction (Philosophical Transactions, 176, Crookes, "On Repulsion," etc., Sec. 134), it has stood the test of time. The perennial stability, however, of many of the stones joined by Crookes to the edifice of science never was questionable. Most of those who have risen to eminence in physics have done so by giving their exclusive attention to that science, and it is only rarely that the physicist can do pioneer work also in chemistry. Rarer still is the case of Sir William Crookes, whose series of physical papers is frequently interrupted by communications concerning his chemical discoveries.

In the Philosophical Magazine of April, 1861, Crookes tells us:

"In the year 1850 Prof. Hofmann placed at my disposal upwards of 10 pounds of the seleniferous deposit from the sulphuric acid manufactory at Tilkerode in the Hartz Mountains for the purpose of extracting from it the selenium, which was afterward employed in an investigation of the selenocyanides."

In the examinat[illegible] the spectroscope, of the residue left in the purification of the crude selenium, Crookes's attention was attracted by a bright green line, which he had never met with before. In following up its appearance, he succeeded in isolating a new metal, which he called thallium, after the emerald green line which has become now as familiar to chemists, even if not brought up in a spectroscopic atmosphere, as the lines of sodium and lithium; and the physicist again and again enjoys the homogeneity of thallium light when observing interference for large differences of path, either with his Rowland or his Michelson grating, or with his Fabry and Perot apparatus, or with his Lummer and Gehrcke plate.

The year 1861 brought the first great triumph to Crookes. During the next twelve years he carried out minute investigations of the many properties of the new element, culminating in his determination of its atomic weight—203.642, or when reduced with the now accepted values for the atomic weights of oxygen and nitrogen, 204.04. Extreme care was given to the necessary weighings, and the pains taken to start with pure substances were enormous. The international committee for the atomic weights and other authorities regard Crookes's determination of the atomic weight of thallium as the best we possess, though thirty-four years have elapsed since the date of its publication.

Crookes finished his determination not without tribulation, having been troubled with discouraging irregularities in his weighings. In order to improve his results, the weighings were made in a partial vacuum, but even under these conditions the balance behaved most capriciously. Sometimes the substance appeared to be heavier when cold than when in a heated condition; sometimes the action was opposite. Working further with indefatigable ardor he came to what he then called "repulsion resulting from radiation," and going on he invented in 1875 an apparatus in illustration of the thoroughly novel and striking phenomena he had observed, the radiometer. His researches in this new field, contained in 485 paragraphs, and published in the Philosophical Transactions of 1874, 1875, 1876, 1878, 1879, represent an immense amount of experimental work of the greatest interest and ingenuity.

Under the influence of the dynamical theory of gases the general nature of the perplexing phenomena was recognized and referred to the intervention of the residual gas. The genius of Schuster, Osborne Reynolds, Tait, Dewar, and Maxwell was associated with this explanation, but special mention should here be made of the more personal, yet beautiful and ennobling example of scientific co-operation given by Sir William Crookes and Sir George Stokes, the documents relating to which have just been published. The new and fascinating chapter in the dynamical theory of gases, relating to the stresses in rarefied gases arising from inequalities in temperature, which thus sprang up in connection with Crookes's experimental work, is, notwithstanding the 110 references to the literature of the radiometer in a modern German textbook, still unfinished. We may be sure that quantitative experiments concerning the radiometer actions under entirely new conditions will again prove the importance of the chapter, emblazoned on its cover by Crookes's light-mill.

Crookes thus was brought into touch with the dynamical theory of gases and with experimental work in high vacua, and so came to his experiments concerning the electric discharge in gases. In this province we are indebted to him for some very striking discoveries relating to the now well-known kathode rays, then already associated with the names of Plücker (1859), Hittorf (1869), and Goldstein (1876). His brilliant experiments ("The Trajectory of Molecules," "Molecular Physics in High Vacua," "Phosphorogenic Properties of Molecular Discharge") were published in the Philosophical Transactions for 1879, but became generally known to the world—not to the scientific world alone—by his lecture on "Radiant Matter," delivered on Friday, August 22, 1879, at Sheffield, to the British Association for the Advancement of Science. Even now the reading of this lecture, though the facts in it have become familiar, brings one under its irresistible charm, and Lenard and Tesla, describing in eloquent terms the impression made by it on their young minds, certainly give utterance to a prevalent opinion. In the beautiful volumes on "Ions, Electrons, Corpuscles," for which physicists are indebted to the Société Française de Physique, only one lecture has been inserted, that of Sir William.

William Crookes.

There exists perhaps only one lecture given on a similar occasion which has become as popular and made on the hearers as deep an impression, both by its contents and its accomplished form; I mean the lecture delivered before the Association of German Naturalists at Stuttgart in 1889 by Hertz, in which his great discoveries were expounded.

All the wonderful and important properties of the constituents of the kathode rays or of radiant matter: its darting in a straight line from the negative pole, the position of the positive electrode being unimportant; its casting of a shadow when intercepted by solid matter; the strong mechanical action radiant matter seems to exert where it strikes; the change of direction by a neighboring magnet; the heat produced when its motion is arrested; the remarkable power which the molecular rays possess of causing phosphorescence in preparations of calcium sulphide shining with blue-violet, yellow, orange or green light, in diamonds shining with nearly all colors of the rainbow, in rubies glowing with a rich full red; all these results Crookes tried to explain by the hypothesis that the kathode rays, or streams of radiant matter, or of matter in an ultra-gaseous state are particles or molecules negatively charged and projected with great velocity from the negative electrode. The inherent truth of Sir William Crookes's hypothesis concerning the nature of the kathode rays is, after much controversy for a space of nearly twenty years, now established, and the original hypothesis, with finer contents, is now accepted by all physicists.

In Crookes's experiments for the first time the majestic simplicity of the kathode rays become clearly apparent. In the irritating complexity of the other phenomena of the vacuum tube, appearances of great purity had been isolated, so that Crookes could risk the opinion "that we are here brought face to face with matter in a fourth state or condition," neither solid, liquid, nor gaseous.

Crookes alone among his contemporaries recognized the essential importance of the kathode rays, and with almost prophetic insight foresaw the part radiant matter would have to play in the development of physical science. In the splendid evolution of electronic theory we are now witnessing, we see how true his foreshadowing of the *rôle* of radiant matter was.

"In studying this fourth state of matter, we seem at length to have within our grasp and obedient to our control the little indivisible particles which, with good warrant, are supposed to constitute the physical basis of the universe. We have seen that in some of its properties radiant matter is as material as this table, while in other properties it almost assumes the character of radiant energy. We have actually touched the border land where matter and force seem to merge into one another, the shadowy realm between known and unknown, which for me has always had peculiar temptations. I venture to think that the greatest scientific problems of the future will find their solution in this border land, and even beyond; here, it seems to me, lie ultimate realities, subtle, far-reaching, wonderful.

"Yet all these were, when no man did them know,
Yet have from wisest ages hidden beene;
And later times thinges more unknowne shall show.
Why then should witlesse man so much misweene,
That nothing is, but that which he hath seene?"

All the experiments in this lecture now have become classical, and several of them are repeated every year in every university of the world. The most familiar and representative of the group is perhaps that one with the Maltese cross in the pear-shaped Crookes tube, in which the black shadow of the cross is projected on the hemispherical phosphorescent end of the tube, in such a manner that a permanent impression on the memory of the student is made.

As an outcome of work recorded in Crookes's various preceding papers, "On Repulsion Resulting from Radiation," etc., and, therefore, with paragraphs numbered in continuation of his "Phosphorogenic Properties of Molecular Discharge," Crookes in 1881 published a research on "The Viscosity of Gases at High Exhaustion." Maxwell's great theoretical discovery that the viscosity of a gas is independent of the density, one of the most beautiful proofs for the reality of molecular motion, had already been the starting-point of experiments by Maxwell himself, Kundt and Warburg, using the method of rotating disks.

In Crookes's experiments the method of observation consisted in noticing the subsidence of the vibrations of a delicately suspended lamina oscillating within a bulb containing the gas. By these simple yet adequate means, very careful measurements were made, and the falling off of the viscosity of different gases from atmospheric pressure to very high exhaustions downward observed, especial attention being paid to the highest vacua and definite measurements made of the

degree of exhaustion employed. At these high exhaustions Maxwell's law completely breaks down, as Maxwell himself foresaw. His observations were discussed in a splendid "note" by Sir George Stokes, another example of the co-operation between these physicists.

Crookes's apparatus afforded at the same time many other data and measurements. The apparent attraction by heat was only found in air of greater than one-thousandth part of ordinary density; while there is repulsion when the density is further increased, the repulsion increasing to a maximum, and thence fading away toward zero as the rarefaction is continued.

In 1881 Crookes's paper on radiant matter spectroscopy appeared. An entirely new method of spectrum analysis is given, based on the well-known fact that under the influence of the kathode rays a large number of substances emit phosphorescent light, some faintly and others with great intensity. Most bodies give a faint continuous spectrum, but more rarely the spectrum of the phosphorescent light is discontinuous, and to bodies manifesting it his attention has been specially directed. This characteristic spectrum is given by the group of elements known as the rare earths, especially yttria in some of its compounds; and in the study of this group the method is of very great importance, and has given, in the hands of Sir William Crookes, at an immense amount of trouble and time, very valuable results. To give, however, an adequate survey of these investigations would demand much space, and uncommon chemical knowledge of the rare earths. We mention only that not long ago Crookes isolated from yttria a new earth, characterized by an isolated strong group of lines high up in the ultra-violet, ascribed by Sir William to a new element named by him victorium.

In connection with his work on the photographed spectra of the elements, of which it seems only a small portion has been published, we record one of his smaller papers, relating to "the slit of a spectroscope," that narrow, but extremely important, gate to a large domain. Crookes makes the very ingenious suggestion to use quartz jaws, cut in the same manner as metal ones. The prismatic edges refracting away all the light which falls on them, their transparency offers no objection, while only the light passing between the jaws comes into operation. As the quartz jaws can be worked to a finer edge, they give better definition.

"With a pair of jaws in the spectroscope at present in use, I can take excellent photographs when they are only 0.0001 inch apart. For eye observation the width can easily be less than that."

Another small paper of date 1879 is also characteristic of Crookes's experimental skill, and illustrates at the same time, if I may say so, the purity of his work. The exceedingly small rate of leak of electricity in a high vacuum is illustrated by Crookes's observation that a pair of gold leaves in a vacuum bulb retains an electrical charge for months.

Of Crookes's recent work, we mention his experimental work on radium. In 1900 Crookes first effected the separation from uranium by two distinct chemical methods of the one direct transformation product, called uranium X. He discovered in 1903 that the alpha rays from radium produce, probably by their bombardment, phosphorescence on a target of crystalline zinc sulphide. This wonderful phenomenon, perhaps the most direct proof of the discontinuous structure of matter, was popularized in his spinthariscope.

These examples must suffice to impart an idea of Crookes's work. "The best history," it has been verily said, "is but like the art of Rembrandt; it casts a vivid light on certain selected causes, on those which were best and greatest; it leaves all the rest in shadow and unseen." What is true in the science of history cannot become untrue in the history of science. It would be desirable to follow a similar precept in trying to picture before our mind the origin of the gratitude and admiration physicists feel for a philosopher, who by his experimental skill, his acute observation, and the continuity of his endeavors, combined with his daring intuition, has impressed indelible marks in different branches of physics and chemistry. This involves, however, more than we can attempt here.

Sir William Crookes is a member or corresponding member of a number of scientific societies in his own country and abroad. At one time or another he has occupied the presidential chair of many of the leading learned and scientific societies of Great Britain. The Royal Society awarded him a Royal Medal in 1875, the Davy Medal in 1888, the Copley Medal in 1904; the French Académie des Sciences, a gold medal and a prize in 1880; the Society of Arts, the Albert Medal in 1899; and he was knighted by the late Queen Victoria in 1897.—P. Zeeman in Nature.

ELECTRIC FISHES.*

EELS AND TORPEDOES THAT USE THEIR BATTERIES ON PREY AND ENEMIES.

BY DR. R. W. SHUFELDT.

ELECTRIC fishes are principally of two kinds, and in classification they belong to two very widely separated groups, for upon the one hand we have the electric eels, and upon the other the famous torpedo fish, or as it is called in England and elsewhere, the cramp, or numb-fish, which belongs among those fishes known as rays and skates. They are all peculiar in possessing in their economies certain electric organs, and these have all the properties of an electric battery or other mechanical devices by means of which the effects of electricity are exemplified.

In general appearance the electric eel departs but little from the common eel of our own waters. Electric eels are inhabitants of the fresh waters of Guiana and Brazil, and especially in the marshes and sluggish streams. There are said to be several species of them, but so far as I am aware the one here to be described is the only species of the family (*Electrophoridæ: Gymnotus electricus*) having the natural electrical apparatus as a part of its organization. This consists of two pairs of peculiarly constituted bodies, passing between the skin and the muscles, longitudinally, in the region of the tail—one pair being next to the back, and the other along the anal fin. Upward of 250 cells make up the structure of one of these organs, and they all receive a very generous nerve supply. Now, when one comes to know that an eel of this species may attain a length of fully six feet and possesses the power to voluntarily give a shock with its battery at any instant when it is not in an exhausted condition, it will at once be appreciated what a truly formidable creature this fish really is. Moreover, it having a smooth, finless back, the body for its entire length being of a dull brownish color above, it becomes quite difficult to see it in the water where it lies, especially if the latter be stirred up and made muddy. It is then that this most powerful of all electrical fishes becomes the most dangerous both to man and beast. Violent shocks and discharges can be given by it, at will, both as a means of offense as well as defense, and these often repeated until its enemy or prey is disabled or stunned; or, what has often happened, sinks into the water to be drowned.

Examination of one of these electrical organs has shown that in action it is very much like a galvanic battery, with the anterior extremity positive, the posterior negative, and the current only discharged at the point of contact with an object. This has been proved to be so powerful when complete that chemical compounds are decomposed by it, and steel needles magnetized.

Different genera and species of the family (*Torpedinidæ*) of electric rays are found in marine waters in various parts of the world, but a brief description of the torpedo of our own Atlantic coast must here stand for the natural history of the entire group. Our Atlantic torpedo, a species which is nowhere abundant, may attain a length of five feet, and weigh as much as 200 pounds. Its form is well shown in Fig. 1 (after Goode), and the location of its electric organs in Fig. 2 (after Gegenbaur). These have much the same character as the corresponding structures in the electric eels, with the same abundant nerve supply. Like most of the rays, the torpedo is a big, disk-like fish of a uniform black color above, with obscure blotches, and white on its under parts. The skin is quite smooth; the mouth is small and the teeth pointed.

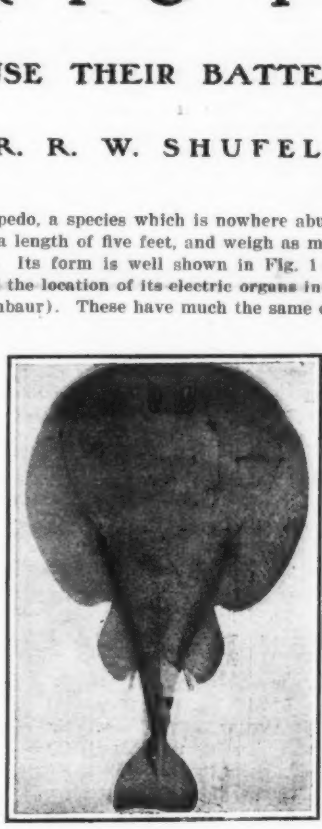


FIG. 1.

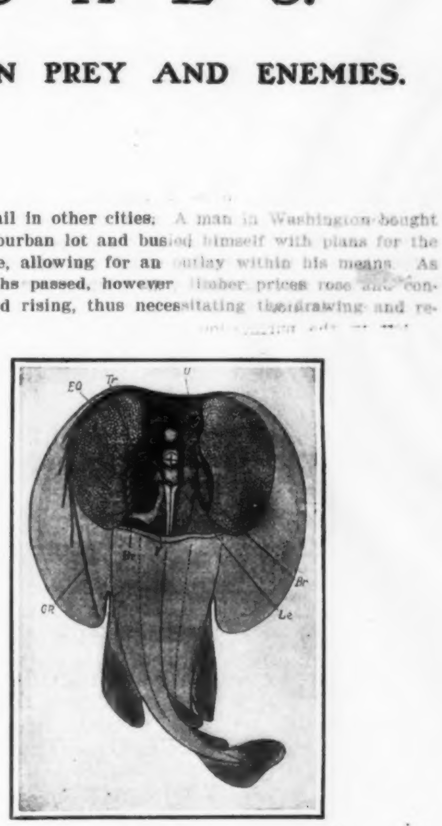


FIG. 2.

THE TORPEDO.

The picture on the right shows the torpedo with the electric organ dissected out (*EO*) (after Gegenbaur). On the right side the dorsal surface only of the organ is exposed. On the left side the nerves which go to it are shown. *Le*, electric lobe; *Tr*, trigeminal nerve; *V*, vagus nerve; *U*, eye; *Br*, gills. On the left are the individual bronchial sacs; on the right the latter are shown covered with a common muscular layer. *GR* indicates the gelatinous tubes of the skin (sense canals).

The fishermen on our coasts often get the torpedo in their pound-nets, and they take great care not to handle them, as a shock from a good-sized one will knock a heavy, strong man down, and paralyze his arms for some time through incautious handling.

* Abstracted from Discovery.

THE WOOD FAMINE.

WIDE publicity is being given to Secretary Wilson's statement regarding the long foretold lumber famine. This famine is no longer an object of merely future dread; it is here.

In Boston, says the Transcript, builders say it now costs 30 per cent more to build a frame house than it did six or seven years ago. Like conditions doubtless prevail in other cities. A man in Washington bought a suburban lot and busied himself with plans for the house, allowing for an outlay within his means. As months passed, however, lumber prices rose and continued rising, thus necessitating the drawing and re-drawing of these plans on a constantly diminishing scale, that they might be kept within the limit of expense originally fixed.

Famine, of course, is a relative rather than an absolute thing. Food famines occur and recur in India. Their existence does not imply the total absence of food from a country, but only its scarcity. In the worst famine some favored ones are as unconscious of existing conditions as was Marie Antoinette when she inquired why the people who could not get bread did not, instead, eat cake. Some go on short rations, some contrive for a time to keep body and soul together, while multitudes perish outright. With the timber famine, the case is already similar. Men of ample means can buy what they want. Inconvenience, however, is already felt; and, as wood becomes scarcer, more and more people will feel the pinch; more and more businesses will be hampered and, in greater or less degree, an effect similar to that accompanying a crop failure or a money panic will be felt.

THE SKY AND THE MOVING OBSERVER.*

CERTAIN APPEARANCES RESULTING FROM MOTION.

BY JACOB B. BROWN.

I have in mind to describe in this paper certain appearances on the star vault which ensue upon certain changes in the position of the observer; and, as many of the circumstances conceived to exist are wholly imaginary, and as some of the positions supposed to be assumed are entirely beyond the limit which it is at present possible to attain, I shall have nothing but the just inferences of science to bear me out in my various statements.

In order, therefore, to insure greater accuracy of conception I may, perhaps, be allowed to remind you that astronomers have the *visible horizon*, whose plane passes perpendicular to the earth's radius through the eye of the observer, and the *rational horizon*, whose plane passes parallel to this through the center of the earth. This latter need not concern us, the distance measured on a perpendicular between the two being a question of high science. When, therefore, the horizon is spoken of it is the visible horizon that is meant, and this is, as far as our intents and purposes extend, identical with the rational horizon; as will, indeed, appear clear when it is remembered that the distance between the two is the length of the earth's radius—about four thousand miles, a quantity which wholly vanishes in face of the other distances which are under contemplation.

As already hinted, it has hitherto been found impossible to reach the neighborhood of the terrestrial pole; and, even had this extreme latitude been attained, it would be very difficult, with the small, portable instruments in use, to locate precisely the point on the surface of the ground about which all others revolve. But there is nothing to prevent our imagining a victory over all these obstacles; and the idea entertained by some men of science that owing to causes, surmised but not perfectly understood, the pole of the earth undergoes a small displacement so as [illegible] records of latitude, is not yet sufficiently rooted and grounded in general faith to detain us at this stage of progress.

The observer, then, at the pole of the earth has the pole of the heavens directly above his head, and his horizon is the equator of the heavens. All the fixed stars of his hemisphere are, theoretically, visible to the polar observer; not practically, for there are refraction, twilight, and obscured horizon to take into account. These fixed stars constantly move round him in circles parallel to the horizon-equator. He never sees the stars of the other hemisphere.

The pole of the ecliptic is at 23 deg. 30 min. from the zenith-pole, and revolves round it as any other point does. The equinoxes are, of course, in the horizon-equator, and can be only vaguely pointed out by reference to stars. The vernal equinox is in the constellation Pisces; the autumnal in the constellation Virgo. These points revolve around the pole as the others do.

It will be noticed that the equinoxes are spoken of sometimes as points, sometimes as seasons of the year. Perhaps it would not be amiss if the language had means of distinguishing for us, as we go along, between the two ideas; but, after all, it matters very little. There is no great difficulty in remembering that the seasons called the equinoxes come round when the sun in his course passes those accurately determined points in the heavens called also equinoxes. It will dwell in your recollection, moreover, no doubt, that one equinox, the vernal, is called the first point of the sign Aries; the other, the autumnal, the first point of the sign Libra.

It follows from all this that the belt of the zodiac, about 18 degrees in width, or nine degrees on each side of the ecliptic, is always half above and half below the equator. Let me say that the visible portion, regarded as a whole, is a semicircle seen in perspective—that is to say, a semi-ellipse, standing on the platform of the horizon like an arch whose crown is 23 deg. 30 min. above the same, and seeming to slide in that position so as constantly to make the circuit of the heavens.

When the sun is coming toward, and reaches the equator, he will be seen by the observer at the pole in the horizon; and will, to all appearances, make one daily circuit in that position. But he is constantly changing declination on the ecliptic, and will, next day, be clear of the equator; and next day still farther away from it. The result is that he rises in a slow spiral until at the solstice, or sun-halt, he is 23 deg. 30 min. above the horizon. He then turns and goes down again, by the same steps but in a reversed spiral, to the equator, where, at the other equinox, he disappears for six months from the view. He then offers, in turn, the same phases to the eye of one at the opposite pole.

And, generally, it will be sufficient to discuss what is to take place at points of the northern hemisphere; the same being true of the southern, with the proper change of data.

The plane of the moon's orbit is inclined to the plane of the ecliptic 5 deg. 9 min. This means that the moon moves on the starry vault within a belt or zone 10 deg. 18 min. wide, half on one side of the ecliptic, half on the other. The moon covers, at one time or another, every point of this zone. It follows from what has been said that, as the ecliptic is always half above and half below the horizon, its highest point being at an altitude of 23 deg. 30 min., the moon will almost imitate the motions of the sun, though with irregular monthly, instead of yearly, periods. As to her being seen, that is another matter. During the long polar day her light, when she is "up," is wholly lost in the beams of the sun; and during the polar night she will revolve within view in a path generally horizontal for about half the time of her circuit; sometimes more than half, sometimes less; the reason of the difference being that she is not on the ecliptic, but only near it, above or below, as already stated. A little pondering may be necessary in order to see this clearly, since the fact is only darkly set forth by the astronomers' statement that the nodes of the moon's orbit are in a constant state of retreat upon the ecliptic.

The movements of the planets are not so simple. The paths they trace upon the heavens are the combined result of their own motions and those of the earth.

Such planets as need concern us remain much nearer the ecliptic than the moon does. Venus, the most extravagant in the correct sense of the word, moves within a zone 3 deg. 23 min. above, 3 deg. 23 min. below the ecliptic. Mercury pervades a belt in all fourteen degrees and a quarter wide, but he is rarely seen. As for the Asteroids, as they are invisible without the aid of a telescope, and not at all impressive when so seen, it will interest us but little to remember that the most extravagant of them, Pallas, has an orbit whose plane is inclined to that of the ecliptic at an angle of more than 34½ deg.

Let the time be summer solstice at the North Pole. The sun is 23½ deg. above the horizon. Let the observer now be transported, instantly, down the meridian on which the sun is, and toward the sun. When he has been moved 23 deg. 30 min. it is clear that he will be on the Arctic Circle; the time of day noon; and the sun at its greatest possible altitude for that parallel. But if the same movement from the pole had taken place away from the sun the observer would have found himself on the Arctic Circle all the same, but at 180 deg. of longitude distant from his previously imagined position. His time would be midnight. The sun would be 23 deg. 30 min. lower than before he moved—in the horizon, therefore, and in the northern horizon, for the visual ray from the sun would pass over the pole.

This is another way of arriving at results which have been stated elsewhere—namely, that the sun just touches the northern horizon at midnight of the summer solstice for the observer on the Arctic Circle; and that at this latitude the extreme altitude of the sun is twice 23 deg. 30 min., or 47 deg. above the southern horizon.

It follows also that the Arctic Circle is, theoretically, the lowest latitude at which the midnight sun can be seen. Theoretically is the word. The fact is, that as the sun is raised by refraction, one can see, as the poet words it,

"The midnight Norway sun set into sunrise."

at a latitude lower by more than half a degree—at Tornea, for instance, at the head of the Gulf of Bothnia, latitude 65 deg. 50 min. 8 sec. north.

Let us not forget to notice at this point an illustration of the difference between absolute time and recorded time which is given by our last conception. The observer, namely, passes instantly from the pole, where it is all hours of the day at once, to noon or, at our will in the same instant to midnight. Our earth has no influence upon time—none whatever. Its motion may be made to record time with more or less correctness; but the responsibility is ours.

Our observer may cross the Frigid or the Temperate Zone at what season or hour he shall see fit, but he will never find a vertical sun.

At the Tropic of Cancer, which is a boundary, he will, at the June solstice, have the sun directly overhead at noon. For one on the other tropic, on the same meridian and at the same hour, the sun is 47 deg. north of the zenith.

The sun is vertical at noon twice a year for all parts of the Torrid Zone, as will be instantly manifest when we remember that precisely one year elapses between the departure of the sun southward from Cancer and his return northward to the same declination.

For an observer on the equator the two poles are in the horizon; and the equator of the heavens divides the visible vault into two equal portions. It follows that at the equinoxes the sun rises at the east point and passes in a circular arch directly overhead to the west point.

The observer at the equator sees theoretically every star in the heavens in the course of the year. To the same observer the sun's daily course is like that of the stars perpendicular to the horizon, whatever be his declination. It follows that he is, on any given day, as long a time below the horizon as he is above it, and that day and night are equal throughout the year. It is for this reason that the equator is called the equinoctial.

It is a necessary consequence of all this and of what has been said concerning the starry sphere as seen at the poles, that at all points between the equator and the poles there are certain stars near the one pole that never rise and others near the other pole that never set. These last are said, somewhat grandiloquently, to be within the circle of perpetual apparition; the others within the circle of perpetual occultation. They are also called, more simply, circumpolar stars. The greatest possible number of circumpolar stars is, of course, one half of the whole.

This word "number" is the most convenient under the circumstances, and, though inexact, is hardly calculated to mislead. What is meant is merely those contained within the confines of one half of the heavens. The number of these may or may not be equal to that of those contained within the other half.

The circumpolar stars at any latitude are readily distinguished. Let the observer conceive a line drawn in his horizon toward the visible pole. This line may easily be conceived as reaching the star vault, and, by the rotation of the earth, describing among the stars a circle with radius equal to the elevation of the pole. All stars within this circle will be manifestly circumpolar. But the elevation of the pole is the latitude of the observer. It follows at once that all stars are circumpolar which are at an angular distance from the pole equal to the latitude of the observer.

The extreme cases are: First, that of the pole, latitude, 90 deg., where one half of the stars are circumpolar; and second, that of the equator, latitude 0 deg., where none are so.

The amplitude of a heavenly body is the arc intercepted on the horizon between the east or west point and the meridian passing through the body.

The amplitude of the fixed stars at a given latitude, though affected by precession, is, to all ordinary intents and purposes, a constant quantity. I say, to all ordinary intents and purposes, which means that any change supervening is so minute that unless there be special occasion to notice it the change may safely be neglected. There is, however, possibility that in the near future we may be addressed by one having authority upon a matter which will include the orientation, as it is called, of Egyptian temples, and alterations in the structure of these from dynasty to dynasty. Both orientation and alteration will be found to have intimate connection with the amplitude of the fixed stars and changes in the same.

The change, on the contrary, from day to day, of the sun's amplitude at rising and setting, is a phenomenon which can hardly fail to impress itself upon any one in the least accustomed to observe the heavens.

We shall endeavor to show that the sun can, when in the horizon, have any amplitude between 0 deg. and 90 deg., according to day and hour and position of the observer. In plainer words, the sun can be seen at certain times and from certain positions at any point of the horizon.

At the time of the equinoxes the sun rises in the east point and sets in the west point for all the world except the very pole. At the pole, namely, there is but one way to look, and that is directly toward the

* Proceedings of the Delaware County Institute of Science.

equator. On that day, accordingly, the sun moves in the horizon, which is the equator for the polar observer.

Confining ourselves for the sake of simplicity, now as before, to the northern hemisphere, since the same reasoning applies to both, it is clear that the inhabitants of the Torrid Zone will, as the sun moves toward the tropic, see him rise and set more toward the north. For a line drawn in the horizon through the sun, the observer and the center of the earth will make an angle toward the north with the plane of the equator, and, consequently, with the observer's parallel.

At the solstice the polar observer can mark no amplitude, as it is defined, when the sun is rising or setting; for the sun is here, for a season, wholly free throughout the twenty-four hours from the circle on which amplitude is reckoned, the horizon namely.

But if it be remembered that at the equator the horizon is perpendicular to the plane of the same, and at the pole parallel to it, and that between these positions its angle with the plane of the equator is constantly changing as the observer moves on a meridian, it will be seen that he at the pole can make the sun touch the northern horizon by moving southward to the polar circle. If the expression may be permitted, he tilts up his horizon to meet the sun. The sun's amplitude at this moment of rising-setting is said, technically, to be east or west 90 deg. north. And, proceeding with the idea, the observer tilts up his horizon more and more as he goes farther south. Now sunrise and sunset are points common to ecliptic and horizon. As the southward movement continues the two circles intercept greater arcs each from the other. The extreme amplitude of east or west 90 deg. north is seen constantly to diminish, until the tropic is reached.

And thus, as the Torrid Zone has already been discussed, the whole hemisphere is accounted for.

When, now, the same has been said, with the proper change of data, concerning the southern hemisphere, it will appear, as stated, that the sun can be seen in every point of the horizon by proper adjustment of season and latitude.

Our conclusions thus far have been reasonably practical; though fancy has aided us to devise the problem which science was to solve. We may look a little farther in the same direction and, if we gain no other advantage from so doing, we shall, at least, have had a wholesome exercise for the imagination.

If one start from the equator and move constantly northeast, his course will be a curve of double curvature, and he will of necessity strike the north pole. For he moves on the surface of a sphere, at an angle of 45 degrees, with a constant series of meridians which converge to the pole. And when the very pole is reached there is but one way to move or look, and that is southward. This fact has been mentioned before, but not the proof of it. We look, namely, east or west along our parallel; and one must leave the pole a short distance behind in order to have a parallel.

It will be understood, with but little effort of memory or imagination, that if one could be instantly transported, say, 90 deg. eastward on his parallel, he would find the time by the clock six hours later than at his starting point; but if the same movement had been made westward he would have found the time by the clock six hours earlier than at his starting point. This state of things is virtually realized by the telegraph. A message leaves London at noon and arrives at Philadelphia, longitude 75 deg. west of Greenwich, so quickly that the time of transit may be wholly neglected. But when it is noon at London it is seven o'clock in the morning here; so that, although starting and arriving at the same moment of absolute time, the message may be said to reach its destination five hours before its starts. If the message went the other way, it would, by the same process of reasoning, take five hours for the transit.

Now these considerations are elementary enough; but see what comes of them if we give our imagination the rein for a moment or two. Suppose our friend at the pole, so often mentioned, should start to warm himself by running round the pole. Whichever way he moved, whether to right or left, he would bring the sun again and again to the meridian before he stopped to take breath; and, unless he took heedful note of the turns and carefully ran the same number in the opposite direction, he would completely upset his record of the day of the month. In fact, by diligent running in the proper direction he might make himself any age he chose. In other words, he could place himself as far back in the past or as far forward in the future as his muscles would carry him.

Again, if he advanced from the pole southward, say, twenty-eight hundred and one yards and a fraction, and then moved on his parallel, he would make the circuit of the earth in ten miles of walking, and as long as he could cover one-twenty-fourth part of this, or seven hundred and thirty-three yards and one foot per hour in a westerly direction, he would keep the sun on his meridian and prevent the date from changing. The great globe would be to him neither more nor less than a magnificent treadmill.

We have gone so far in our conceptions and placed our observer in such hitherto impossible places, that we may as well pass over into miracle for a moment, eliminate gravity, station him, without visible means of support, directly above the pole of the earth, and see what comes of it.

The atmosphere, which is virtually part of the earth, and whirls around with it, has no influence whatever upon this suspended man, for he is at the neutral axis. He sees the earth revolve beneath him once in twenty-four hours, and points upon it have but a slow motion; for, as we have seen, an object 8,404 feet from the pole would move but 733 yards in an hour, and a point close to the pole only twice as fast as the hour hand of a watch.

The stars have no courses; they are fixed forever in their places. They are but a permanent background. The sun appears at the equinox, moves in six months through the half of the ecliptic which is above the horizon-equator, then disappears at the other equinox, and is seen no more for half a year.

The moon rises at her appointed time, and not far distant from the point where the sun appears. For about a fortnight she is constantly above the horizon; then goes down, on the side opposite to her rising. Needless, perhaps, to remind you that during the polar day her beams are lost in those of the sun.

The planet Mercury and the planet Venus, being inferior planets, will be seen before the sun's yearly rising in the constellation Pisces, and after his yearly setting in the constellation Virgo. The path they trace upon the heavens will be as it is to the ordinary observer upon the earth's surface, a curve far from simple—the combined result of their own movement and that of the earth.

The superior planets may at the appointed times be seen, all through the long polar night, just as they may all through the short terrestrial night. When, namely, they are on the opposite side of the equator to the sun they will be seen; when they are on the same side they will not be seen.

Now, I wish my observer to move down the meridian toward the equator, still preserving his disconnection with the earth. But if he do so move he will, from causes set forth above, have a wind abeam to contend with, constantly increasing in force until, at our latitude, for instance, it will have a speed of 766 miles per hour, and at the equator a velocity of 1,000 miles per hour. He could not endure this. It would tear him into little pieces just as if he had been blown from a gun. So we will suppress the wind as we have suppressed gravity—the one operation being as easy as the other—and we will have him move at will up and down the meridian, merely taking care not to be in the track of oncoming terrestrial protuberances.

Nor must he in his wholly unaccustomed freedom from the influence of gravity forget, lest his records fall into confusion, that a straight line drawn through him away from the center of the earth is said to point upward, and through him toward the center of the earth, downward—wherever he may be.

Let his first stop be at the Arctic Circle at the time of the summer solstice. If we have moved down the meridian away from the sun he will, at the halt, find the sun in his northern horizon. But the horizon is here the ecliptic of the heavens, as set forth elsewhere; and it follows that as long as he remains over the polar circle he will see the sun make yearly circuit of the horizon; never rising, never setting. The surface of the earth moves away eastward beneath him at the rate of more than 400 miles per hour, and he does not distinguish objects.

But when he has reached the latitude of the equator, all is flying beneath him at the rate of a thousand miles an hour, and is reduced to one uniform color and surface; though he may, possibly, distinguish land from sea. He looks up and finds that one half the stars he saw when at the pole have disappeared from view and others have moved up from the opposite quarter to fill their places. They are all now motionless, as before.

The moon and the planets order themselves as when he was at the pole, but at different levels.

The sun rises in Pisces and sets in Virgo after six months; but the altitude he reaches is 66 deg. 30 min. above the horizon, instead of 23 deg. 30 min.

And now, when our privileged associate has assured himself by the faithful witness of the eye concerning these and many other wonderous things which he knew before by theory, and when he has duly steeped his soul in the tremendous loneliness of his position, he may, if he sees fit, return to his native latitude and drop back among his friends.

According to a recent industrial report the largest labor organization in the world is the Deutscher Metallarbeiterverband—German Metal Workers' Union. At the close of 1906 the membership was 335,075 and during the past year funds collected amounted to $1,880,000.

THE EXCAVATION OF ANCIENT MEMPHIS.

ONE of the most important enterprises in connection with the operations among the buried and long-forgotten cities of ancient Egypt is the systematic excavation of Memphis, one of the greatest capitals in the old world, about which comparatively little is known. Memphis long since vanished beneath the sand, yet it was perhaps the most important city of ancient Egypt, since its history extends over the whole course of Egyptian history. It contained the finest school of Egyptian art, and in wealth was unrivaled.

But the progress of time through successive centuries has left few visible traces. The ground upon which it once stood, and below which a great part remains buried, is now farmed, but the sites of the various temples are plainly discernible. To save the last remaining links with the past, the work of excavation should be carried out as quickly and as thoroughly as possible, and this work is now in hand. Failing to obtain state aid, the British School of Archæology has taken the project boldly in hand under the superintendence of Prof. Flinders Petrie, who has been so closely associated with similar work in the country during recent years. It is anticipated that fifteen years will pass in the excavation of the temple sites alone, apart from the city, and that an expenditure of $15,000 per annum will be incurred. The temples alone cover over one hundred acres, which is a greater expanse than all the area of Karnak. The principal temple was that of Ptah, a vast building originally founded by Menes, but doubtless rebuilt upon a more magnificent scale by the pyramid sovereigns, and enlarged by a great pylon on the north—a work carried out under Amenemhat III. From time to time further improvements and additions were made during successive dynasties. Rameses II. added colossi in front of the temple, Rameses III. built a portico facing to the west, Psammitichos erected a southern portico and also the court for the sacred Apis, while Aahmes added a huge colossus 75 feet in height before the temple. Adjoining this temple was that of [illegible] spacious and magnificent pile, while south of the Temple of Ptah stood the temple of the foreign Aphrodite surrounded by the Tyrian Phœnicians.

It is in this foreign quarter that Prof. Flinders Petrie is hopeful of making his richest discoveries, since it must have been the emporium of Ægean trade during the prehistoric ages of Greece. Here the Egyptologists expect to find the remains of the early civilization of the Mediterranean.

These ruins of temples were standing, as in the case of those of Thebes, up to seven hundred years ago, when they were dismantled for the provision of building material for Cairo. The foundations, however, and sculptures still remain beneath cultivated fields. It is confidently anticipated that the remains that will be unearthed will be in an excellent state of preservation, judging from the discoveries that have already been made upon this site of statues which were found to have their faces perfectly intact. To facilitate the excavations the work will be carried out gradually, the villagers being presented with other tracts of land as their fields are dispossessed. Half of the discoveries according to the law will become the property of the Egyptian government, the remaining half reverting to the British School of Archæology, so it is evident that those museums which support the undertaking will receive a capital return in the form of antiquities for their contributions to the enterprise.

Finds during the past season have considerably widened our knowledge of the manners and customs of ancient Egypt. At Ghizeh the School of Archæology has succeeded in tracing the first, second, and third dynasties and the civilization soon after the foundation of Memphis has been proved to be equivalent to that of the south at Abydos. The relics unearthed, comprising stone vases, objects wrought in ivory, and flint, antedate the dynasties of the pyramid builders by many centuries. The school also succeeded in finding a considerable quantity of anthropological material of the later times, which has been taken to England for further and more complete investigation and study.

The discoveries that were made at Rifeh near Asyut were even more valuable, since here a complete equipment of a tomb of the twelfth dynasty was brought to light. It was of the best work and in perfect condition, two coffins covered with painting, the canopic box, two boats, and five statuettes being of the finest quality. A long series of the curious pottery soul-houses were recovered, which explain this quaint development of religious thought; and also the appearance of the actual dwellings of the peasantry in the Middle Kingdom, with the details of construction and furniture. By means of this discovery the first opportunity has been presented for the complete study of this interesting subject. There were also brought to light many early Coptic settlements, which yielded stone inscriptions and carvings, papyri, leaves of

parchment, MSS., etc. Altogether the results of the past season's operations have been among the most prolific, varied, and valuable in the work of the British school, the discoveries ranging from the first to the thirtieth dynasty. Work is to be resumed upon this site during the present winter until the ground becomes sufficiently dry to commence excavations upon the ruins of ancient Memphis.

ENGINEERING NOTES.

During the construction of the Thames tunnel, somewhere about the year 1828, Brunel, the celebrated engineer, found great difficulty in boring through the soft clay beneath the river without running a terrible risk of an inrush of water. While examining one day a piece of timber honeycombed by the burrows of the ship worm, he conceived the idea of the boring shield in several sections, which is so generally used at the present day. The ship worm, or teredo, varies in length from a few inches to a yard, and is cylindrical and worm-like in its appearance. The anterior end, lying at the bottom of its burrow, is somewhat enlarged, and bears a pair of shells or valves. In the smaller species the body is not larger than a pencil, and its shells are so very small they are frequently mistaken for jaws. Great damage is done to wooden boats and ships by the borings of these creatures.

In a recent number of Engineering, J. E. Petavel describes with sketches fittings for hydraulic or gas pressure work, suitable for maintaining such pressures as 30,000 pounds per square inch, and occasionally reaching as much as 45,000 pounds per square inch. Generally a metal-to-metal joint is found essential. For the highest pressures, steel tubes were found to be best, as copper, after safely withstanding 20,000 to 30,000 pounds for a week, would fail upon reloading at a lower pressure. The steel tubes were jointed thus: the end of one portion was coned, that of the other fitting cupped; the coned end carried a flange which was screwed on and brazed; for the rest the design was that of an ordinary union. Pressures up to 15,000 pounds were obtained by means of a pump with automatic valves, but for higher pressures a screw-actuated ram, with hand-operated valves, was brought into action.

The effect of compressed air on health has lately been under investigation by two English engineers, who submitted themselves to some heavy pressures during the tests. A steel chamber was built, according to the Engineer, in which the pressure was frequently raised to 75 pounds per square inch, without serious effect on the experimenters. Other tests showed that it is possible for a man to endure a pressure of 92 pounds per square inch without unpleasant results, provided that, first, at least twenty minutes be allowed for taking off each 15 pounds of pressure, the decompression being at a uniform rate; and, secondly, that the capillary circulation in every part of the body be maintained by muscular action during decompression. The only inconvenience under the pressure noted was a little temporary neuralgic pain in the arms. The studies further led to the belief that the longer the exposure, the longer and more uniform should be the decompression.

E. Heyn in Stahl und Eisen systematically considers the occurrence of internal stresses in castings or forgings, through differences in the rates of cooling of different parts of the piece. The method employed is that of the discussion of the behavior of two pieces of metal clamped together, which are at different temperatures; and besides the case of perfect elasticity, two others of importance arise, viz., when the elastic limit is exceeded, and when the plastic limit is exceeded. The "plastic limit" is here the temperature above which the material flows plastically under stress. In order to study the occurrence of internal stresses in cooling, a knowledge of the plastic limit may be obtained by heating two pieces of the metal clamped together in such a manner that one is in tension, the other in compression. The temperature at which the stresses disappear is the plastic limit. The disappearance of stress is to be detected by measurements made between marks on the bars. Examples of castings which have cracked in cooling are described.

Announcement has been made by the Wyoming Historical and Geological Society that the one-hundredth anniversary of the burning of anthracite coal in a grate will be celebrated in Wilkesbarre on February 11 of this year. Judge Jesse Fell, of Wilkesbarre, burned coal in a grate for the first time at the old Fell tavern on the night of February 11, 1807. Previous to that date, coal, known generally as stone coal because of its hardness, was without commercial value, since the people of those times believed that it would not burn with sufficient readiness to make it of any use. Judge Fell, however, felt that if correctly used coal would make a practical fuel, so he built a simple grate of iron bars, and before some of the most prominent men of his city, made a test that gave to anthracite its present commercial value. The night was bitterly cold with a high wind, making a fine draft up the chimney. Before long the coal in the grate glowed, and sent out a grateful heat. News of his success spread rapidly, and people built grates in their homes, digging into the outcroppings for the new fuel.

ELECTRICAL NOTES.

To prepare wooden separators for use in accumulators, H. Leitner, according to Centralblatt Accumulatoren, treats the wood by saturating the pores with a hypochlorite solution, which on addition of acids is decomposed and yields chlorine, which latter eliminates the undesirable substances in the wood, and can itself be extracted by washing without damage to the woody structure. The wood is first boiled in water for 12 hours, the water withdrawn, and 0.5 per cent calcium hypochlorite solution added, after which the wood is washed. It is then kept in sulphuric acid of 1.01 sp. gr. for 12 hours, and finally boiled for three successive periods of 6, 12, and 18 hours. Such separators can be kept in the air, especially if boiled for 24 hours in a 0.125 per cent solution of tragacanth. Another method of freeing the wood from harmful substances, and making it porous, is disclosed by C. Haunz and the A.B.P. Accumulator Company, Ltd., in Brit. pat. 17,539 of 1906. The wood is here treated with caustic alkali solution under pressure. The boards are put in 5 to 10 per cent hot sodium hydrate solution for 6 to 8 hours under a pressure of 9 atmos. above atmospheric. The brown to black-colored treated boards are quickly washed in running water, and immersed in 3 to 6 per cent sulphuric acid for a short time. The original color of the wood is thus restored. The separators must be stored in water or weak acid as usual, but the treatment is very rapid and simple. A third patent, that of the Akkumulatorenfabrik-A.G., describes a process whereby only the resinous substances are extracted, the starchy elements being left in the wood to assist in maintaining the capacity of the negative plates. The wood is treated with alkaline solutions of hydroxides, carbonates, silicates, or borates.

Ionization by bubbling is discussed by M. de Broglie in a recent issue of Comptes Rendus. The intensity of ionization depends greatly upon the size of the orifice. Feeble for capillary tubes, it passes through a maximum, and becomes very feeble again for large diameters. If aspiration takes place through a bubbler with a fine tube open to the atmosphere, and the depression is varied, the current indicated by the electrometer varies slowly at first, and then in proportion to the difference of pressure. Adding different salts such as NaCl, KCl, KI, $BaCl_2$ gradually, and tracing curves with concentrations as abscissæ and currents as ordinates, it is found that with positive charges the ionization, very feeble at first, rises rapidly, passes through a flat maximum for about millinormal concentration, and then tends to a constant value. For negative charges the maximum is more decided, and occurs at 1/2000 normal; the curve then falls, cuts the former curve at 1/100 normal under an acute angle, and then falls slowly. It follows that the total charge is negative at first, then zero, and finally positive. Dilute solutions of HCl, H_2SO_4, KOH, NaOH, and acetic acid show the same general behavior. In the first (rising) branch of each curve the sensitiveness for very slight variations of concentration is very great. Adding alcohol to water there are no maxima at feeble concentrations, but ionization increases regularly, attains that of pure alcohol at 30 per cent, and then remains steady. By the influence of Röntgen rays or radium rays the gases ionized by bubbling through a salt solution have their conductivity reduced to 1/6 or 1/10. On the other hand, gases bubbled through benzine, toluene, and essence of terebenthine, which are non-conducting, acquire conductivity. They evidently contain neutral centers chargeable by radium rays. The presence of such centers in air before bubbling greatly increases its subsequent ionization.

M. Kroll, in Elektrotechnik und Maschinenbau, after a general discussion of the problem of balancing high-speed machinery, describes the following method of securing balance. Two balancing disks, with suitable grooves for receiving balancing weights, are provided, one at each end of the rotor. The bolts holding down the caps of the bearings are slackened, so that each cap is free to move through a small distance in a vertical direction. Above each cap is arranged a device for measuring the upward thrust of the bearing. The device consists of a strong flat metal capsule, formed by two castings bolted together, and divided into two compartments by a membrane. The upper compartment is filled with an air-free liquid, and is connected to a manometer. The lower compartment is nearly filled by the expanded head of a pin which is attached to the membrane. This pin passes freely through a suitable guide-hole and rests on the cap of the bearing. Any upward displacement of the cap will compress the liquid in the upper compartment of the manometric capsule, and the amount of pressure so produced will be indicated by the pressure gage. The rotor, which has previously been balanced statically, is provided with an additional pair of weights, a weight being placed in each balancing disk, the weights being equal and at the same distance from the shaft but on opposite sides of it. The rotor is run up to speed and the reading of the pressure gage noted. The diametral plane containing the weights is then gradually shifted until the pressure gage gives a minimum reading. By now altering the values of the weights without altering their positions, the pressure may be made to vanish, and the dynamical balance may be regarded as sufficiently good for practical purposes. Still more perfect balance may, however, be obtained by continuing the alteration in the weights until the pressure gage once more begins to read. If w_1 is the value of each weight which just causes the reading to vanish, and w_2 that which just causes it to reappear, then $\frac{1}{2}(w_1 + w_2)$ will give practically perfect balance.

SCIENCE NOTES.

The desirability of finding a substitute for albumen—the best known form of which is the ordinary white of egg—is not sufficiently appreciated. In "Der Weltstreik," a German story by an anonymous author, a millowner is shown as receiving the thanks of a professor whom he has financed for some years. "It is certain that the discoverer of a method of making artificial albumen would banish all distress from the world for all time. . . . It would be interesting to know what sum had been necessary for the discovery of how to make artificial albumen and the banishment, for all time, of hunger from the world. I am sure that it would be ridiculously small beside the figures of one year's budget of the army and navy of a single European great power." The result of such discovery, and its value, are not exaggerated by the unknown author.

When a plane train of sound waves falls upon a small spheroid or disk, formulæ expressing the scattering effect have been given by Rayleigh, who employed a method based on an analogy with potential theory. The formulæ are first approximations, holding only when the ratio of linear dimensions to wave-length is very small. The deduction of more accurate expressions requires the use of harmonic analysis, which has been given by Rayleigh for the case of the sphere. A paper by J. W. Nicholson in the Philosophical Magazine develops a suitable harmonic analysis for treating obstacles of other than spherical shape, and applies it to (1) a prolate spheroid of small ellipticity, (2) a long thin blade, (3) an oblate spheroid, (4) an approximately spherical planetary body, and (5) a circular disk. The methods and results are unsuitable for detailed abstraction.

C. Barus suggests a possible analogy between geyser-like action and periodic solar disturbances in a recent number of Science. Let a curve *td* represent the relation between temperature and depth below the solar surface. Let another curve *tp*, on the same diagram, represent the relation between temperature and depth which is the condition for transition from an atomic form A to an atomic form B. Then the transition will occur at depths below the solar surface given by the ordinates of the points of intersection of the two curves *td* and *tp*. Suppose, as a first alternative, that after a sun-spot period the *td* line has been depressed by the sudden cooling of all active strata to a position *t'd'* completely below *tp*. The points of intersection have vanished. B matter only is present. In the lapse of time, however, owing to heat arriving from below, the line *t'd'* again rises until it intersects *tp*, when another eruption occurs, which drops the *td* line to *t'd'* in turn. The depression of this line is relatively sudden; its gradual rise, together with the properties of the AB system, determines the frequency of the sun-spot period; the element A escapes (let us say) in gaseous form. The relations of the curves *td* and *tp* will vary with the solar latitude; on passing from pole to equator *tp* shifts bodily from left to right (depth being supposed represented by abscissæ). At the poles A may thus be permanently absent, while at the equator *t'd'* may never fall below *tp*. Hence an intermediate sun-spot zone may be inferred. As a second alternative, the transition of A into B may be supposed a source of heat, and the ensuing eleven years an interval of cooling, the cycle of changes being reversed.

TABLE OF CONTENTS.